ENVIRONMENTAL ANALYSES IN MARINE FISHERIES RESEARCH -

FISHERIES ENVIRONMENTAL SERVICES

edited by

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PREPARATION OF THIS DOCUMENT

The need for synoptic information on oceanographic and marine meteorological conditions as a basis for marine environmental services was stated as early as 1964 by the FAO Advisory Committee on Marine Resources Research (2nd Session, Rome). Since then, a means for gathering such data on a world-wide basis was established - the IOC/WMO Integrated Global Ocean Station System, IGOSS.

Marine fisheries environmental services, on the other hand, developed their own systems for coding and transmission of data on a national basis following the needs of the specific types of fisheries they are serving.

This document describes the main existing fisheries services, their systems of data collection and the preparation and dissemination of resulting products, in order to provide suitable material for further discussion of the related problems on an international level. In addition it is intended to encourage similar efforts for the application of synoptic environmental data to improve the fishery efficiency also in other fishing areas.

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ABSTRACT

In the first part of the paper the relationships of the behaviour and population biology of marine fishes to environmental conditions are reviewed indicating the kinds of oceanographic data which are useful to fishermen and fishery managers. The general characteristics of the services needed to provide such information are considered along with methods of obtaining the data needed quickly and efficiently. Ten examples of operating environmental services of various countries are discussed in detail in the second part of the paper, along with a review of other services, either proposed or implemented, for which less detailed information is available.

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ENVIRONMENTAL ANALYSES IN MARINE FISHERIES RESEARCH - FISHERIES ENVIRONMENTAL SERVICES

PART I: SCIENTIFIC AND OPERATIONAL CONSIDERATIONS

by

G.H. Tomczak

1. INTRODUCTION

Although world fisheries production rose rapidly through the 1960's to reach a total of 70.3 million tons by 1971 no further expansion took place until 1975 (FAO, 1976). In 1976 a further increase in the total catch of about 4 percent to an estimated amount of 73 million tons was noted.

In the light of a previous estimate that it would be necessary to nearly double that production to meet minimum requirements for fish in 1985 (FAO, 1968) the development of total world catch during the early 1970's stresses the need for appropriate management of fisheries and in this connexion, for intensive fisheries research.

Gulland (1977) has pointed out that problems of stock and recruitment, interaction between species, and inherent variability of natural systems have to be solved in order to base management of fisheries on a broader concept than the simple maximum sustained yield.

As important as this type of research is, in fact, for the scientific basis on management decisions in fisheries, the application of research data for the benefit of fisheries should also be considered worthwhile (Kesteven and Deacon, 1955; Chapman, 1972). A considerable amount of data and knowledge of life histories of various species, their environmental requirements and their behaviour has been gathered in the past. The time now seems ripe to translate the results of such research into practical applications for the economic benefit of fisheries, and the present predominantly biological-statistical fisheries research may be supplemented by a branch of fisheries environmental services (Laevastu and Johnson, 1971).

The basic objective for such services would be to assist fishermen in better planning for fishing operations and in searching for harvestable fish concentrations.

Assuming that appropriate information could be given to reach this goal these services would be of potential economic value by saving searching time and thus, running expenses for fishing boats and their crews. This again, would help to keep prices at a reasonable level and thus, to make fish protein available to people with low incomes in developing countries.

A presupposition of such services, however, is that meaningful relations between the occurrence of harvestable fish concentrations and some easily observable environmental parameters are known, and that changes occurring in the availability of fish by reason of environmental changes, as well as the effects of these changes on the reproductive success of fishes and on fluctuations in the number of recruits, may be predictable to a satisfying extent.

Although this may not yet be the case for some fisheries - and still more research is first needed for their behaviour as regards migration, spawning, wintering places, uniformity of distribution in the water column, etc. in response to changes in the ocean - it can be stated that for a number of commercial species, meaningful relations between their abundance and availability and oceanic parameters have been found which may be used by environmental services to raise the efficiency of fishing operations as well as for long-term fisheries management.

Laevastu and Hela (1970) have prepared a valuable compilation of such relations, and corresponding papers on the results of recent research since then are included in the list of references (see also Table 1, page 22). If such relations are combined with the application of other important data on fisheries - such as the traditional geographical distribution and abundance of fish populations, the water depth in spawning and fishing areas, the type of bottom preferred by the various species, the trawlability of the bottom - fisheries environmental services seem to be feasible and economically rewarding based on gathering synoptic observations of environmental parameters and data on fish catches and landings.

The need for synoptic information on oceanographic and marine meteorological conditions as a basis for such services was discussed more than ten years ago by FAO's Advisory Committee on Marine Resources Research at its second session in Rome (ACMRR(FAO), 1964). It is stated in the report of that session "that such information is necessary for planning fishing operations and ocean research and that it would have practical applications in expanding world fisheries".

In consequence, an ACMRR Working Party on Fishermen's Charts and Utilisation of Synoptic Data was established "to examine what information is now available and is now in a properly usable form and to study where the need is greatest for such maps and summaries" (Terms of reference; ACMRR(FAO), 1964, loc. cit.).

The Working Party concluded that, although a growing realization of the need of fishermen and fishery oceanographers for average and synoptic marine meteorological, oceanographic and other information for fishery activities was in evidence, the application of such information for the improvement of fishery efficiency and the development of world fisheries was not widely in use outside Japan. It was recommended, therefore, to "consider the merits of preparing and publishing a description of the available fishermens' charts and their utilization to promote wider application in other regions of the world" (ACMRR(FAO), 1967).

The present paper follows this suggestion providing detailed information on fisheries environmental services which prepare oceanographic analyses and forecasts and which are established, for the benefit of their national fisheries, in Australia, France, Japan, Republic of South Africa, U.S.A. and U.S.S.R. (see part II).

As is well demonstrated by the description of these services they all stress the need to establish intelligent collaboration between the services, research scientists and users of the information published by the services as it is felt that all of them could considerably profit from such interaction.

On the one hand, success in better understanding of the behaviour of fish in response to environmental changes will result in greater accuracy of environmental analyses and predictions whilst, vice versa, the need for better predictions may additionally justify governmental support to basic research, and, on the other hand, fishermen will be more willing to provide good and more numerous environmental observations if the scientists conducting these services would be able to interpret their analyses in terms understandable and usable for them.

2. FISH BEHAVIOUR IN RESPONSE TO CHANGES IN ENVIRONMENTAL CONDITIONS

Main emphasis in this paper is given to the description of established marine fisheries environmental services (part II).

It is obvious that such services will depend substantially on sufficient understanding of the behaviour of fish in response to changes in environmental conditions whereby the terms "behaviour" in this case is used in a slightly restricted sense, referring to the reaction of schools and, at times, of the entire stock of a given species to given environmental parameters and their changes.

Such reactions were soon realised in fisheries research. In fact, special studies of this kind already lead, at the end of the last century, to the first international cooperation between fisheries scientists in northern and western Europe and, eventually, this cooperation resulted, in 1902, in the formation of the International Council for the Exploration of the Sea (ICES), a body which, since then, acted as a promoter for further studies on relations between fisheries science and hydrography.

2.1 Changes in environmental conditions

As regards the effects of environmental changes on the behaviour of fish, reference is made to the book by Laevastu and Hela (1970) which summarizes the state of knowledge in this field and also gives examples on the interaction between fish and its environment. The main literature which since then has been published on related topics, has been compiled in the form of a table (Table 1) which shows the relationship between environmental and fisheries parameters that have been investigated by the authors, for species, and oceanic areas. It should be pointed out however, that the compilation is by no means complete. There are numerous papers in this field being scattered over a great number of journals which could not all be studied by the author. The table is based on checking Vol.1(1971) to Vol. 7, No. 5 (May 1977) of Aquatic Sciences and Fisheries Abstracts, ASFA (FAO/IOC, Aquat.Sci. Fish.Abstr.).

On the oceanographic side the investigations are in most cases chiefly concerned with effects of the thermal regime of the water on the behaviour of fish. This does not always mean that the authors have defined real cause-effect relationships; the investigations are based rather on statistical evaluation of time series without discussing the possible mechanisms involved. In most cases changes in temperature and in horizontal or vertical temperature gradients have been taken only as an indicator for what has happened in the environment with regard to any effects on a certain species behaviour. The reason for this being that, on the one hand, water temperature is one of the easiest observable environmental factors for which a large number of observations are available in the archives of national and world data centres, and that, on the other hand, experiments have shown a real dependence of fish behaviour - such as spawning, migration, schooling - from temperature values within certain "preferred" limits.

Besides such investigations on effects of temperature and its changes a significant number of studies also refers to the influence of currents and water masses, thus, providing good observational material for use of these factors for the prediction of the behaviour of fish stocks to any changes in the environment.

All the environmental services described in part II are based on the observation and prediction of the above oceanographic parameters, i.e. the temperature regime, the current pattern and/or the distribution of water masses. Some of these services, however, also take into account very specific features, such as bioluminescence, rainfall, water colour or turbidity. The relevant references which may be of special interest are given in Table 1.

Once again, it should be pointed out that most of these studies have analysed only the effects of one environmental feature on fish behaviour and distribution. The interaction of the fish and the environment, however, is extremely complex, and it is obvious that a number of features and processes will jointly affect fish populations. More emphasis must be given in future research to interacting factors and processes, and the availability of high speed computers may permit to do this in order to come to a more realistic appraisal of fish behaviour and distribution.

2.2 Changes in fisheries parameters

As regards the fishery parameters listed in Table 1, it is well-known that they vary with the intensity of fishing effort, and changes in the yield of any particular population of living marine resources may not necessarily reflect any changes in the environment. Instead of this they may be related to a small number of breeding adults in the population resulting from too heavy fishing and from other causes for variations in year class strengths, e.g., the lack of abundance of proper food at the proper time, or the abundance or shortage of competitors for food during the early life stages of a species. However, much year class variability is most probably attributable to variability in the environment which leads to fluctuations in food, predators, etc.

The whole life history of a commercial species - spawning, recruitment, reproduction - is closely dependent upon the environmental conditions. It is postulated, therefore, that oceanography, at least, after further related studies have resulted in a better understanding of relations to the behaviour of fish stocks and to a better understanding of physical processes in the oceans, will be able to assist fisheries by the formulation of corresponding prediction systems.

Various examples of this kind are given by Yudovich and Baral (1968) for several commercial species in different regions of the ocean and by Østvedt (1971) for the Norwegian herring fishery. The latter may be explained in more detail as it is instructive concerning the correct understanding of the role of environmental parameters for the life history of a specific population.

2.3 Herring fishery as an example

Østvedt (1971, loc. cit.) shows how, for a long period of time, temperature charts could be used successfully to locate herring at any time of the year because research on their behaviour related to water temperature had resulted in a good knowledge of the herring migration route throughout the year.

Approaching the Norwegian coast the winter herring tended to gather in cold water pockets between Iceland and Norway before crossing, with increased swimming speed, the warm Atlantic current in order to penetrate into the colder Norwegian waters and to spawn there at temperatures between 6° and 8°C but avoiding areas with sea surface temperature below 5°C.

Disappearing in May/June from coastal waters after spawning the herring migrated to the boundary areas between the cold East Icelandic Current and warm Atlantic water masses.

With this information on the migration route of the herring it has been possible to establish a service which could direct the offshore fishing fleet to the fish concentrations in the cold water pockets, and could predict - with fairly high accuracy and considerable economic gains - the arrival of the herring in the spawning area. In addition, since 1952, special cruises were jointly organized by various ICES member states in the Norwegian Sea which enabled the fisheries services of participating states to make pre-season forecasts.

In all cases the forecasts were based primarily on temperature observations: observations at fixed stations and on board coastal steamers in coastal and offshore areas (Eggvin, 1940), observations on temperature distribution at 20m depth during the jointly organized cruises in summer (Østvedt, 1971).

Although very good results were obtained with these forecasts for many years, eventually it was found that the knowledge about the influence of environmental factors on herring migration and distribution was still insufficient, taking into account only the actual temperatures. For instance, after the herring spawned in 1958 and 1959 in the more northern parts of Norwegian coastal waters because the hydrographical conditions on the southern coast were rather unfavourable, they did not return to the southern area in later years in spite of the fact that the water temperature returned to normal values providing favourable conditions for spawning there.

Similarly, changes in the behaviour of herring related to the environment could be found in the areas where the herring stays during the summer months. Since 1965 the temperature on the north coast of Iceland has fallen below a threshold value for the herring and the herring has since migrated to more favourable conditions in the northern part of the Norwegian Sea. Again, although favourable conditions north of Iceland have been restored later the herring did not return.

These examples show that sudden changes in environmental conditions may well change the migration pattern of a fish stock for several years beyond the time when "normal" conditions again exist. Services, therefore cannot be based, for the time being on definitely established relations but need flexibility to make the best use of new results of research in this field.

2.4 Established relationships

A number of such studies which may be used for the development of prediction systems are listed in Table 2. These studies may provide the basis for forecasts on fish catches, fishing grounds, fish distribution, fishing periods, abundance of commercial species, and others.

In part, the results of these investigations have been used with success in assisting fisheries and in forecasting, at least, the trend of the fishery for better management. With more experience gathered with such relationships and with more fisheries scientists willing to offer a good deal of their professional time for environmental services, more such services may be established in the future for the benefit of fishermen.

W.M. Chapman predicted - in his forword to the book by Laevastu and Hela (1970) - that within a few years forecasts and analyses will be going to many more kinds of fishermen in many more parts of the world, that they will be of much increased reliability and that these will be having ponderable effects on the profitability and development of fisheries on a broad scale around the world".

3. ANALYSES OF ENVIRONMENTAL CONDITIONS

As predicted by Chapman there are in fact, a growing number of fisheries environmental services (see part II) which provide assistance to national fisheries by analysing the environmental conditions and by estimating, based on such analyses, the distribution and abundance of a given stock.

3.1 Data base and communication systems

Sources of oceanographic observations for environmental summaries are still limited within existing internationally organized systems.

So-called "ships of opportunity", being part of the WMO system, regularly provide observations on weather and the sea state including sea surface temperature. More recently a special ships' code for subsurface temperature observations (bathythermograph recordings) has been developed by the IOC/WMO Integrated Global Ocean Station System (IGOSS) which allows research vessels and ships of opportunity to transmit these data together with routine weather observations to coastal radiostations from where these data are channelled through the WMO communication system to relevant service centres.

Additional temperature data as well as other observations, such as salinity, currents, turbidity, water colour, are made available from cruises of research vessels, commercial vessels enlisted by oceanographic institutes to make special observations, and miscellaneous other sources, e.g. shore stations and fixed oceanographic stations (platforms or buoys).

Some of the oceanographic observations acquired from the above sources are obtained routinely but most measurements are made on an ad hoc basis as part of specific research cruises. These data are obtained over relatively wide geographic regions. Only seldom therefore the number of observations reaching an environmental service centre without time delay is sufficient to prepare an analysis which represents the actual distribution of a given oceanographic parameter (Wolff, 1970).

Besides this shortcoming concerning the geographic distribution of observations there is another one which is related to the transmission time of data with the effect that the bulk of data exchanged internationally through agreed exchange systems is of no use to environmental services. Whilst these services do need the data immediately, i.e. on a "real-time" basis, the exchange system developed by oceanographers makes the observations available to users with only a considerable time-delay, gathering them first in national, regional and world data centres before they are distributed to users.

On the other hand, the IOC/WMO Integrated Global Ocean Station System (IGOSS) developed to overcome these shortcomings has not been found to satisfy national fisheries environmental services which must have regard for customers to keep confidential, at least, parts of the messages which are transmitted by fishing vessels to them. This is the reason why all services described in part II have developed their own observations and communication system, including aerial or even satellite observations, to cover their region with a sufficient number of timely available observations.

3.2 Types of fisheries environmental services' products

As the observations as such are only of little value to fishermen and other potential users, they are worked up by fisheries environmental services. The products prepared by these services correspond to two different types:

(i) Analyses/short-term forecasts

Analyses demonstrate the present state of environmental conditions and are taken as a basis to draw conclusions regarding the behaviour of a given fish population, also making limited "extrapolations" of the environmental conditions for a short time period.

In general, these analyses deal with

- determination of distribution and abundance of a given stock as determined by optimum and/or limiting environmental conditions,
- estimation of dispersal, aggregation and vertical migrations as determined by the synoptic conditions and shortly after,
- estimation of direction and speed of migration, depth of occurrence of fish schools, etc.
- forecasting weather and sea conditions as affecting fishing operations.

(ii) Mid-term and long-term forecasts

Mid-term and long-term forecasts for environmental conditions are based on climatic considerations and corresponding changes in the heat content of oceanic regions. In this context the possibility of application of hydrodynamical numerical models has been pointed out (Laevastu, 1969; Laevastu and Johnson, 1971). From such environmental forecasts conclusions may be drawn concerning the behaviour of commercial species, e.g. reproduction, changes in migration routes. Additionally, for forecasts on the yield of a given fishery, regression equations have been calculated based on statistical considerations (Table 2, page 29).

Thus, forecasts are aimed at:

- estimating natural fluctuations of fish stock as determined and influenced by environmental changes,
- estimating the date of arrival of a given species to their spawning grounds,
- forecasting weather and sea conditions as affecting fishing management.

Existing environmental services, as can be seen from part II, are mainly working with the first category of products; they prepare analyses and interpret them on a short-term basis for the users. The second category, especially long-term forecasts on resources of commercial species, are provided, more or less on an ad hoc basis, by single research workers rather than by services (Bogdanov et al., 1975; Tyurnin, 1973; Uda, 1974; Yudovich and Baral, 1968). However, in the future, well proven relationships will certainly also be taken into account by environmental services to prepare long-term forecasts.

The analyses prepared by fisheries environmental services for short-term forecasts cover the following marine meteorological and oceanographic parameters:

- Weather analyses, summarizing the evaluation of a number of meteorological parameters. For the safety of fisheries activities these analyses/forecasts should, in the future, also be prepared both for coastal fishing areas, as the local coastal weather may differ considerably from that on the land and that farther offshore, and for medium range periods to allow better fishery planning (Laevastu, 1966).

- Sea state, i.e. waves, ice coverage, icebergs

- Temperature (surface, subsurface, bottom water temperature) and temperature anomalies.

Such analyses/forecasts would automatically provide distribution maps showing the mixed layer depth, the depth and intensity of the thermocline and upwelling areas. Whilst temperature maps for many regions may be representative even if observations from periods up to ten days are used for an analysis (e.g. Mittelstaedt, 1969), the processes of upwelling or the dynamics of current patterns may need a higher frequency of analyses referring to short-period observations only (Tomczak Jr. and Miosga, 1976; Cram, see part II).

- Currents

The important role which the current pattern plays in analysing environmental conditions for any forecasts in fisheries can be seen from the description of marine environmental services given in part II. Some attempts have been made, therefore, for synoptic analyses and forecasting of surface currents (Hubert and Laevastu, 1967).

Further progress in this field may be expected from more systematic use of satellite observations (Joseph and Stevenson, 1973; Strong and De Rycke, 1973; Szekielda, 1976). At the present time, there are, however, only few direct current observations available to environmental services on a real-time basis.

- Plankton

Similarly, as with currents, only very few distribution maps for plankton, indicating good or bad food conditions for fish, have been prepared, so far. Again, some progress may be possible using remote sensing from plane or satellites for the production of such maps on a more regular basis (Szekielda, 1971, 1974).

So far, fisheries environmental services are preparing almost exclusively so-called SST charts (i.e. maps showing the distribution of the sea surface temperature). A great number of such charts is channelled through the WMO communication system and transmitted to potential users by radiostations using the facsimile system. In Table 3, SST maps are listed which are routinely available at the Japan Fisheries Information Service Center. [1] Considering that still more such maps are produced and distributed by meteorological and oceanographic services (e.g. Cram, part II) one can envisage the importance given to temperature as a factor affecting environmental processes and living resources. However, quite a considerable duplication of work seems to be done in this field and agreements about the different responsibilities could probably save valuable time and make environmental services more effective.

One should also bear in mind that experience gained by various fisheries environmental services (Østvedt, 1971; Cram, part II) has shown that these maps are not in all cases sufficient to interpret the behaviour of fish, especially its distribution or aggregation in the area of investigation. More systematic use has therefore to be made of bathythermographs to explore the subsurface temperature structure (Laevastu and Johnson, 1971) and thus, to complement the information contained in SST charts.

3.3 Potential use of satellite observations for environmental analyses and forecasts

Besides the direct assistance given to fisheries by visual air spotting of fish schools, remote sensors are used successfully on board aircraft to assess environmental conditions and to monitor fish distribution (see part II). Techniques have been developed to measure the sea surface temperature with high accuracy and space resolution and, connected with it, the heat flux, thermal fronts and the upwelling intensity and variability (McAlister, 1968; Woods and Watson, 1970; Tomczak Jr. and Miosga, 1976), the ocean colour and thus, chlorophyll and plankton (Smith and Baker, 1977; Sams, 1971; Szekielda, 1971), and bioluminescence of plankton (Bertouch, 1976; Malan et al., 1977). Also other features of interest to fisheries are investigated and promising first results have been obtained which may become usable in the future, e.g. the spectral reflectivity by fish oil (Benigno, 1971).

These successful uses of remote sensing techniques from aeroplanes in fishery research and commercial fisheries lead to speculations about their potential use from spacecraft (Stevenson and Pastula, 1971; Joseph and Stevenson, 1974; Stevenson, 1975).

From the experience gained so far, it can be concluded that, although satellites will not replace most of the traditional approaches to fisheries research and management, data acquired with remote sensors from spacecraft will considerably improve understanding of coastal fishery resources if integrated well with those from the more traditional platforms and facilities and if effectively analysed in "real-time".

It should be pointed out however, that in all probability the direct monitoring and assessment of fish stocks through space observations at least for the near future, seem to be unlikely.

The real potentiality for the use of remote sensors from spacecraft appears to be in the application of environmental measurements assuming that relation to the behaviour of fish has been established accordingly.

At present, remote sensors from spacecraft observations are available for surface temperature measurements, temperature gradients and anomalies showing upwelling areas and current boundaries (infra-red and micro-wave radiometers), for measurement of circulation patterns and eddies of water masses (colour and multispectral cameras)(Szekielda, 1976), and for the dynamics of sea ice (Kaminski, 1975; Le Schack, 1975); great success has also been achieved in measuring chlorophyll and plankton (Yentsch, 1973; Szekielda, 1971, 1974). In summarizing the present research results and bearing in mind the development of further techniques one can conclude that, in a foreseeable future, satellites will provide, on a routine basis, world-wide data on the sea state, surface wind fields, sea ice, chlorophyll, suspended sediments and temperature and salinity, the latter two not only for the sea surface but also, for instance, by using the laser technique for subsurface layers down to possibly 100m depth.

[1] Copies of these maps were kindly made available to the editor by Dr. E. Okada, Director,

In some fisheries satellite data are already used, on a "real-time" basis, to provide fishermen with valuable information on fish aggregation (Breaker and Jurick, 1975; Gorman, 1976; see also part II). In addition, during the last few years, pilot experiments have been executed in connexion with the launching of various research satellites which have proven that space observations will be able to contribute significantly to the effective management and utilisation of coastal fishery resources. In this connexion the pioneering investigations by the National Oceanic Atmospheric Administration (NOAA), National Marine Fisheries Service, U.S.A., should specifically be mentioned. Besides the papers given under (i) to (iii) below the papers by Woods et al. (1975), Glidden and Kemmerer (1976), Bullis, Jr. and Kemmerer (1976), Savastano and Leming (1977), Vanselous (1977), and Kemmerer, Savastano and Faller (1977) are of particular importance.

Reference is made to three projects:

(i) ERTS-1 Menhaden Experiment. The investigation showed that multispectral scanner measurements can successfully be correlated with Menhaden distribution (Kemmerer et al., 1974; Needham, 1975)

(ii) LANDSAT Menhaden and Thread Herring Resources Investigation. This is a follow-on of the first project which was initiated in 1975. First results showed that approximately 90 percent of the known Menhaden locations reported by the fishing fleet fell into areas of high probability of Menhaden aggregation as found from colour, turbidity and chlorophyll-a measurements of the satellite. After problems of near "real-time" processing of LANDSAT data had been solved information on probable location of Menhaden was disseminated to the fishing fleet within 21 hours after satellite reception (Woods et al., 1976; Kemmerer and Butler, 1977; Kemmerer et al., 1977).

(iii) Skylab-3 Gamefish Experiment. This study was conducted in 1973 off the coast of western Florida and showed that significant relationships between white marlin distribution and remotely sensed measurements could be established. The best correlations were found with colour data from the multispectral scanner aboard Skylab-3 and a prediction model for the distribution of white marlin could be developed (Savastano, 1975).

Some further experiments are executed or being suggested which will widen the scope of applications of remote sensed data from satellites. For instance, Creswell (1976) made successful use of satellites for locating drifting buoys. As such buoys follow the circulation pattern and may tend to concentrate in frontal zones of different current systems they could service as indicators for areas of tuna aggregation. Cram (1977) investigates the possibilities of using satellite observations for the krill fishery based on the surface discolouration attributable to krill and visible to reflected daylight sensors in connexion with krill bioluminescence visible to low altitude sensors. It may be added that satellites will also provide a unique opportunity of continuously following any changes in the circumpolar course of the antarctic polar front. Kemmerer et al. (1977) describe a project on Fisheries Surveillance Investigation designed around the spacecraft SEASAT-A which is scheduled to be launched in 1978. The study will be aimed at determining if space surveillance of fishery vessels is a practical alternative to the more conventional techniques. And, finally mention should be made of the Nimbus-G satellite which will be launched in the fall of 1978. This spacecraft will be equipped with two instruments specifically designed for observations over the oceans, i.e. the Scanning Multichannel Microwave Radiometer (SMMR) and the Coastal Zone Colour Scanner (CZCS) (Anon., 1976; D.S. Johnson, pers. comm.). The CZCS will allow the measurement of ocean colour with high spectral resolution being the only instrument out of those presently planned for space systems which will penetrate into the ocean surface; the amount of penetration depending on the attenuation by water, the amount of seston and the absorption and scattering characteristics of the sestonic material. It will have a wide scope of applications, including water mass dynamics, ecosystems, the bio-optical state of the surface layer, living marine resources and environmental quality.

3.4 Geographical structure of fisheries environmental services

As can be seen from part II the existing marine fisheries environmental services are established as national services, initiated and highly supported in some cases by fishery companies. In view of the different requirements for the specific fisheries for which the services are established, and in view of the fact that much of the incoming data have to be kept confidential, considering competition between the companies or even the single fishing boats, each service has developed its own system for coding and transmission of data and disseminating the products. At the present stage of the development it seems unlikely that a world-wide observational system, such as IGOSS which, in addition, has only a limited possibility to provide "real-time" data on, for instance, currents, salinity, plankton, bioluminescene or fish schools, can be tailored to satisfy the varying requirements of fisheries environmental services.

If any development of fisheries environmental services beyond the national level would be possible, this could only be tested on a regional level. Some pilot experiments of this kind have already been executed.

Possibly the best example is the ICES Pilot Project on Rapid Utilization of Synoptic Oceanographic Observations (Eggvin, 1966). Eight European countries contributed data to this study which was aimed at providing synoptic observations to describe the temperature and salinity distribution at the surface and various depth horizons in the North Sea, the waters around the British Isles and the Norwegian Sea. Corresponding analyses together with diagrams showing the vertical distribution were prepared and distributed by airmail with a time delay of only a few days. Forecasts concerning some fisheries and data on ice formation as well as distribution of characteristic water masses were added and described in bulletins.

The project was carefully prepared by a specially established ICES Sub-Committee for Telegraphic Communications of Oceanographic Observations and proved to work well during the period for which it was planned. It seems that the inputs to be given by the participating national institutes were not found to be balanced sufficiently against the efforts needed and the real use for the various national fisheries. The pilot project did not enter into a continuous phase.

A similar experience was encountered by I. Yamanaka (pers. comm.) in gathering temperature observations covering the whole tropical Pacific Ocean from various national services in Japan, Australia and the U.S.A. providing SST charts for the use by tuna fishermen. The charts were found useful, in principle, by the users but had limited value because they could only be issued with a time delay of some weeks. The pilot project therefore, was not continued.

Finally, regional collaboration which proved to be successful was organized by some ICES member states (Denmark, Iceland, Norway and the U.S.S.R.) to survey the distribution and abundance of herring in relation to environmental factors during the time after spawning when the herring disappears from the coastal Norwegian waters and is then usually found feeding in the boundary areas between the cold East Icelandic Current and the warm Atlantic watermasses.

This collaboration resulted in charts showing the temperature at 20m depth. With changes in the migration of herring, however, the interpretation as presented in these charts could not indicate the development expected during the following months. It was left to the experience of the participating scientists to give forecasts on abundance and migration of herring on a national level which then also took into account specially gathered plankton data. This experiment therefore also cannot be taken as a really successful regionally based fisheries environmental service.

Up to now, experiences seem to confirm what was already stated in the ACMRR working paper on "Rapid Utilization of Synoptic Oceanographic Data, Fixed Stations and Biological Data Exchange" prepared for the second session of ACMRR(ACMRR(FAO), 1964a). The paper suggests that, if synoptic oceanographic maps of the ocean climate in a specific region are envisaged, the necessary preparations should be discussed and organized by regional working groups. Compilation of data on a world-wide level should be taken into account only as a next step. In this case, maps developed for the various sub-regions have to be made compatible with each other, gaps in the scientific knowledge to understand sufficiently the behaviour of commercial species in the regions have to be defined, and environmental products have then to be given in terms understandable and useful to fishermen.

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Table 1: Relations between fish behaviour and environmental parameters

Relation between																	Species	Area	Reference
SST (Sea surface temp.)	BWT (Bottom water temp.)	Temperature gradient	Salinity (S)	T/S relation	Oxygen	Water colour	Currents	Water masses	Others*	Fish distribution	Fish aggregation	Yield/catch	Fishing period	Yearclass strength	Spawning	Eggs and larvae			
			X	X							X						Skipjack tuna	Pacific	Barkley, 1969
		X									X						Various	Eastern Mediterranean	Ben Yami, 1973
								X			X						Blue whiting	Norwegian Sea	Blindheim et al., 1973
		X	X		X						X						Various	Bay of Bengal	Bogdanov, 1973
X					X				N		X						Tuna	Indian Ocean	Bozhkov, 1973
X		X								X	X						Albacore, salmon	Eastern Pacific	Breaker and Jurick, 1975
									B		X	X					Mackerel	Singapore waters	Burdon, 1954
X							X					X					Pilchard	S. African coastal waters (Atlantic)	Buys, 1959
	X									X					X		Plaice, haddock	U.S. coastal waters (N-Atl.)	Colton,Jr., 1972
X	X									X	X						Various	-	Coutant, 1977
X							X					X					Tuna	Brazilian waters	De Moraes, 1967
X		X								X	X						Herring	Norwegian Sea	Devold, 1969
X														X	X	X	Cod	North Sea	Dickson et al., 1974
	X								T	X						X	Redfish	Northeast Atlantic	Dietrich et al., 1961
X	X									X							Cod	Barents Sea	Dommasnes et al., 1974
	X										X						Lobster, shrimp	U.S. coastal waters (N-Atl.)	Dow, 1964, 1969

* see foot of table

Table 1: (cont'd)

Relation between																	Species	Area	Reference
SST (Sea surface temp.)	BWT (Bottom water temp.)	Temperature gradient	Salinity (S)	T/S relation	Oxygen	Water colour	Currents	Water masses	Others*	Fish distribution	Fish aggregation	Yield/catch	Fishing period	Yearclass strength	Spawning	Eggs and larvae			
X									U	X		X					Various	Oceanic upwelling areas	Dragesund, 1971
	X	X									X				X		Halibut	Icelandic waters	Ernst, 1974
X			X				X			X							Salmon	Pacific coast, Canada	Favorite, 1969, 1969a,b
X										X							Sockeye salmon	Bering Sea	Fujii et al., 1974
X										X	X						Menhaden	Gulf of Mexico	Gallaway and Strawn, 1974
X	X									X					X		Various demersal	-	Golikov and Skarlato, 1972
X		X									X						Mackerel	Korean waters	Gong et al., 1972
									B		X	X					Mackerel	Malaysian waters	Gopinath, 1950
	X											X					Cod, redfish	Icelandic waters	Hallgrímsson, 1955
		X			X					X	X						Striped marlin	Baja California	Hanamoto, 1974
X							X					X					Various	Japan adjacent seas	Hanaoka, 1972
									P	X							Tuna	Angola Basin	Herbland and Stretta,1973
X							X									X	Cod	West Greenland	Hermann et al., 1965
	X									X		X					White pomfret	East China Sea	Higashikawa, 1974
X							X			X		X					Tuna	Western tropical Pacific	Inanami, 1941
X		X						X		X	X						Herring	Norwegian Sea	Jakobsson, 1969,1971

* see foot of table

Table 1: (cont'd)

Relation between																	Species	Area	Reference
SST (Sea surface temp.)	BWT (Bottom water temp.)	Temperature gradient	Salinity (S)	T/S relation	Oxygen	Water colour	Currents	Water masses	Others*	Fish distribution	Fish aggregation	Yield/catch	Fishing period	Yearclass strength	Spawning	Eggs and larvae			
X										X	X						Anchoveta	Peruvian waters	Jordan, 1971
X		X								X							Tuna	Inter-tropical Atl.	Kawai, 1969
X						X			Ch	X		X					White marlin	Gulf of Mexico	Kemmerer, Savastano and Faller, 1977
						X			T/Ch	X		X					Menhaden	Gulf of Mexico	Kemmerer *et al.*, 1977
	X			X				X					X				Sole, cod, pollack	Bering Sea	Kihara and Uda, 1969
	X						X					X		X	X		Cod	Norwegian waters	Kislyakov, 1959, 1961
X								X				X					Mackerel	E. China - Yellow Sea	Kondo, 1969
X	X											X					Cod	Barents Sea	Konstantinov, 1967
X	X						X			X		X					Cod	Labrador Sea	Konstantinov, 1968
									P					X			Kilka	Baltic Sea	Krüger, 1972
X		X				X	X			X							Tuna	-	Laevastu and Rosa, Jr., 1963
		X						X		X							Albacore	U.S. coastal waters (Pacific)	Laurs and Lynn, 1975
X		X						X	U	X	X						Albacore	U.S. coastal waters (Pacific)	Laurs *et al.*, -
X			X				X					X					Salmon, trout	Korean waters	Lee *et al.*, 1973
X	X									X							Various	U.S. coastal waters (N-Atl.)	Lenz and Seydlitz, 1972
									B		X	X					Sardines	U.S. coastal waters (Pacific)	Linder, 1930

*see foot of table

Table 1: (cont'd)

Relation between																	Species	Area	Reference
SST (Sea surface temp.)	BWT (Bottom water temp.)	Temperature gradient	Salinity (S)	T/S relation	Oxygen	Water colour	Currents	Water masses	Others*	Fish distribution	Fish aggregation	Yield/catch	Fishing period	Yearclass strength	Spawning	Eggs and larvae			
						X			Tu			X					Brown shrimp	Gulf of Mexico	Linder and Bailey, 1969
X								X		X		X					Whales	Indian Ocean	Machida, 1975
	X											X					Cod, redfish	Icelandic waters	Magnússon, 1955
	X	X										X					Cod	Barents Sea	Midttun, 1965
X												X					Stenella	Japan adjacent seas	Miyazaki, 1974
X							X			X	X				X		Cod Haddock	Barents Sea	Mukhin and Sarynina, 1974
X		X					X					X					Oil-sardine mackerel	Indian coastal waters	Murty, 1965
X							X	X				X			X		Various pelagic	Japan adjacent seas	Nakai et al., 1967
X							X			X							Tuna	-	Nakamura, 1969
							X	X		X							Whales	N. Pacific, Bering Sea	Nasu, 1974
X										X	X						Various	Australian waters	Natarov and Pashkin, 1968
						X			Tu		X						Menhaden	Gulf of Mexico	Needham, 1975
X					X				MR			X	X				Mackerel	Indian coastal waters	Noble, 1972
X	X	X							P	X		X			X		Herring, cod	Norwegian Sea	Ostvedt, 1965, 1970
									P					X			Anchovy	Black Sea	Pavlovskaya, 1973
X							X			X					X		Capelin	Barents Sea	Penin, 1973

* see foot of table

Table 1: (cont'd)

Relation between																	Species	Area	Reference
SST (Sea surface temp.)	BWT (Bottom water temp.)	Temperature gradient	Salinity (S)	T/S relation	Oxygen	Water colour	Currents	Water masses	Others*	Fish distribution	Fish aggregation	Yield/catch	Fishing period	Yearclass strength	Spawning	Eggs and larvae			
X									P					X		X	Tiulka	Sea of Azov	Pinus, 1973
								X	N/U	X							Tuna	Waters around Madagascar	Piton and Magnier, 1976
		X						X		X	X						Tuna	Tropical Atlantic	Postel, 1969
X			X						MR/P	X							Various pelagic	Indian coastal waters	Prabhu *et al.*, 1974
X										X		X					Tuna, bonito	U.S. coastal waters (Pacific)	Radovich, 1963
X												X					Oil-sardine, mackerel	Indian coastal waters	Rao *et al.*, 1973
X			X							X						X	Tuna	Tropical Atlantic	Richards, 1969
X						X		X		X		X					Albacore	Waters around New Zealand	Roberts, 1971, 1974
X			X		X		X			X							Tuna	Chilean and Peruvian waters	Sandoval, 1971
X										X		X					Mackerel	Japan adjacent seas	Sato, 1974
							X			X	X				X	X	Skipjack tuna	Hawaiian waters	Seckel, 1972
									B		X						Mackerel	U.S. coastal waters (N-Atl.)	Sette, 1950
		X		X	X			X		X		X					Prawn	Indian coastal waters	Sharma and Murty, 1973
	X		X		X						X	X					Various	South China Sea	Shirota, 1973
	X							X		X	X						Prawn	Yellow Sea	Shojima and Otaki, 1971
							X	X	U		X						Whales	N. Pacific Bering Sea	Shurunov, 1970

* see foot of table

Table 1: (cont'd)

Relation between: SST (Sea surface temp.)	BWT (Bottom water temp.)	Temperature gradient	Salinity (S)	T/S relation	Oxygen	Water colour	Currents	Water masses	Others*	Fish distribution	Fish aggregation	Yield/catch	Fishing period	Yearclass strength	Spawning	Eggs and larvae	Species	Area	Reference
									B		X						Mackerel	Indian coastal waters	Silas, 1967
X										X	X						Tuna	Waters around Sri Lanka	Sivasubramanian, pers.com.
	X									X	X			X			Haddock	Barents Sea	Sonina, 1969
X											X	X					Striped marlin	U.S. coastal waters (Calif.)	Squire, 1974
	X	X									X	X					Cod, redfish	Icelandic waters	Stefánsson and Jónsdottir, 1974
X									R/Ti			X					Menhaden	Gulf of Mexico	Stone, 1976
X			X		X					X						X	Tuna	Gulf of Guinea	Stretta, 1976
X		X	X					X	U		X	X					Tuna	Gulf Guinea	Stretta *et al.*, 1975
		X						X			X	X					Various	Gulf of Thailand	Suzuki, 1973
X		X	X			X				X							Herring	Okhotsk Sea	Takahashi, 1976
X		X					X	X		X	X						Salmon	Japan adjacent seas	Tanaka, 1965
X										X		X					Yellowtail	Japan adjacent seas	Tanaka, 1975
	X	X								X							Cod, haddock	Atlantic	Tatyankin, 1972
X		X						X		X		X					Tuna	Indian Ocean	Tsurudome, 1970
X										X				X	X		Herring	Okhotsk Sea	Tyurnin, 1973

* see foot of table

Table 1: (cont'd)

Relation between																	Species	Area	Reference
SST (Sea surface temp.)	BWT (Bottom water temp.)	Temperature gradient	Salinity (S)	T/S relation	Oxygen	Water colour	Currents	Water masses	Others*	Fish distribution	Fish aggregation	Yield/catch	Fishing period	Yearclass strength	Spawning	Eggs and larvae			
							X	X	U		X	X					Tuna	Indian Ocean	Uda and Nakamura, 1973
X							X	X		X	X						Mackerel	Yellow Sea	Ura and Mori, 1971
X			X					X			X						Tuna	Gulf of Guinea	Voituriez et al., 1973
X								X				X					Butterfly mackerel	Japan adjacent seas	Wareshina and Hisada, 1972
X	X	X								X		X			X		Various	-	Wawrowski, 1976
X											X	X					Skipjack tuna	Pacific Ocean	Williams, 1970
X											X						Coho salmon	U.S. coastal waters (Pacific)	Wright et al., 1976
X		X					X	X		X							Tuna	Tropical Pacific	Yamanaka, 1969
X		X		X			X	X		X	X		X		X		Various	W- and N-Pacific	Yudovich and Baral, 1968
X		X		X			X	X		X	X		X		X		Various	Atlantic Ocean	
X		X		X			X	X		X	X		X		X		Various	Indian Ocean	
X	X						X			X					X		Alaska pollack	Japan adjacent seas	Zver'kova, 1974

Key:

B = Bioluminescence
Ch = Chlorophyll
MR = Monsoon Rainfall
N = Nutrients
P = Plankton

R = Rainfall
Ti = Tides
Tu = Turbulence
U = Upwelling

Table 2: Established Relationships between Fisheries and Environmental Parameters Aimed at being used for Short-Term or Long-Term Forecasts

Relationship established between	Regression Equation (Correl. Coeffic.)	Forecast/Comment	Species	Region	Reference
Water temperature at fixed stations and catch of fish (in tons). Based on long-range catch statistics including, to some extent, consideration of fishing effort	Yes (0.77 to 0.92)	Prediction of catch with different time lags for the various species (1-7 years). The temperature has been used by the authors as "an indicator" also taking into account that for it the best and longest continuous records are available	Various, esp. cod, haddock, yellow-tail flounder, menhaden	U.S. coastal waters (N. Atlantic)	Sutcliffe et al., 1977
Bottom water temperature at fixed stations and yield of lobster (in tons)	Yes	Prediction of catch taking into account mean temperatures of preceding winter months and mean annual temperatures 6 to 8 years previous to the year for which prediction is made	Lobster	U.S. coastal waters (N. Atlantic)	Flowers and Saila, 1972
Water temperature in sub-surface layers (200-300 m, 300-400 m, and others) and percentage of catch of cod in various sub-areas as compared with total catch in the whole area	Yes (0.70 to 0.96)	Prediction of location of the best areas for scouting cod, some (2-6) months up to one year in advance	Cod	ICNAF Sub-area 1 (W. Greenland)	Svetlov, 1970
Water temperature in 100 m depth at a fixed station and fish catch (tons/hour)	Yes (-)	Prediction of minimum catch for different temperature intervals one month in advance. The temperature has been used as the best indicator for upwelling processes in the region	Various Scomber species	Gulf of Mexico	Gonzalez, 1975

Relationship established between	Regression Equation (Correl. Coeffic.)	Forecast/Comment	Species	Region	Reference
Heat content of surface layer (0-200 m) or ice coverage or annual river discharge to the area of fisheries or mean annual water temperature at standard sections - These terms related to each other in various combinations	Yes (-)	Prediction of heat content in surface layers of the investigated fishing grounds which is used for estimation of reproduction of commercial species	Various	Various regions of the N. Atlantic	Izhevskii, 1964 Bogdanov et al., 1968
Water temperature at standard section, "index" of cod (or haddock) resources and annual catch (in tons) in the whole fishing area or in parts of it	Yes (0.73 to 0.95)	Prediction of catch (taking into account the temperature related distribution of the resource in the area) one year in advance	Cod, haddock	Barents Sea	Mukhin and Ponomarenko, 1968
"Cold" and "warm" years and catch per trawling hour in different sub-areas	Yes (-)	Prediction of catch in various sub-areas some months in advance based on the fact that warm years cause an easterly distribution of resource and vice versa (Østvedt, 1971)	Cod and other bottom fish	Barents Sea	Ponomarenko, 1968 Konstantinov, 1967
Water temperature in surface layer (0-50 m), planktonic biomass per m^3 and average catch of 0-class cod (number per trawling hour). Temperature and zooplankton measured "in the main stream of the Murmansk Current"	Yes (0.84 to 0.95)	In view of only limited number of data used the author qualifies formulae as not yet satisfactorily predicting at that early stage of investigation. Research is continued	Cod	Barents Sea	Degtyareva, 1970
Water temperature in surface/sub-surface layer (0-500 m) at standard section and distribution of fish. Based on the fact that heat content in the southern Barents Sea affects mass migration of cod to the east	Yes (0.83)	Prediction of fish distribution 3-6 months in advance of starting trawl fishery off West Spitsbergen	Cod	Barents Sea	Konstantinov, 1973

Relationship established between	Regression Equation (Correl. Coeffic.)	Forecast/Comment	Species	Region	Reference
Water temperature at fixed station, outflow of Dnjepr River and yield of sprat	Not calculated but graphically shown	With material from selected years authors believe that predictions are possible for yield of sprat one year in advance considering temperature and river outflow	Sprat	Black Sea	Yuryev and Starushenko, 1974
Water temperature in surface layer (0–50 m) in a limited offshore area and size of pilchard catch	Yes (0.95)	Prediction of size of pilchard catch 1 year in advance of fishing season	Pilchard	South African offshore water (Atlantic)	Buys, 1959
Monsoon intensity (represented by the difference in atmospheric pressure between Cochin and Bombay) and oil-sardine catch (in tons)	Yes (-0.84)	Prediction of the "trend of the fishery" in advance of the fishing season. The relation is valid only until a "critical value" of monsoon intensity. However, taking fishing effort into account (not yet done by the authors) the relation will possibly alter	Oil-sardine	Offshore waters of west India	Murty and Edelman, 1971
Mean daily rainfall during several two-weeks periods in June to August and oil-sardine catch (in thousands of fish per gear). Rainfall taken as "symptomatic of general climatic conditions that would control spawning"	Yes (-)	Prediction, about two months in advance, the prospects of the commercial fishery for the juveniles	Oil-sardine	Offshore waters of west India	Antony Raja, 1974
Water temperature in the surface layer (0–10 m) of fishing area and herring yields (in tons). Sufficiently high food value of the sea territory is a necessary requirement	Yes (0.83)	Indicating areas of best yields during daily fishing operations. Yield of more than 200 kg/net to be expected for temperatures between 7.5 and 10.5°C. No yield when temperature is <4° or >13°C	Okhotsk herring	Sea of Okhotsk	Chernyavskiy, 1970

Relationship established between	Regression Equation (Correl. Coeffic.)	Forecast/Comment	Species	Region	Reference
Period of large school formation and time of peak spawning, the latter being water temperature dependent	Yes (0.72)	Prediction, about 3 months in advance, of period of large school formation where schools are comparatively slow-moving and purse-seines are most effectively used	Okhotsk herring	Sea of Okhotsk	Elkin, 1973
"Upwelling index" and crab catch	-	Prediction of crab catch "for ensuing years". Besides the upwelling index other factors, such as water temperature and result of plankton tows have to be considered	Crab	U.S. coastal waters (Pacific)	Botsford and Wickham, 1975
Average annual water temperature in subsurface layer (0-200 m) at a standard section and reproduction of commercial fish	Yes	Long-term forecasts (5-10 years) for the thermal regime in the North-Atlantic with estimating consequently reproduction of fish	Various	N. Atlantic	Bogdanov et al., 1968 and 1975
Water temperature in 150-200 m depth at standard section and size of catch by trawling	Yes (0.67)	Prediction of catch 2-3 months in advance	Bottom fish	Barents Sea	Konstantinov and Svetlov, 1974
Water temperature and ice coverage during spawning period and distribution of fish	-	Forecasting "to a certain degree" distribution of fish during the spawning period enabling planning research operations at the beginning of the foraging period	Okhotsk herring	Sea of Okhotsk	Tyurnin, 1973
General relationships between environmental conditions, particularly current pattern and resources of commercial species	-	Long-term forecasts based mainly on state and foreseeable changes of current pattern (Kuroshio, Oyashio, Tsushima Current)	Various	Japan adjacent seas	Uda, 1974

Table 3: Sea surface temperature charts, distributed through WMO channels or by facsimile via coastal radio stations [1]

Area	Geogr. Coordin.	Period	Office	Comment
All oceans. Northern and southern hemisphere	-	)weekly with)12 hourly)updating	Fleet Numerical Weather Facility, Monterey, California, U.S.A. [2]	Numerical computer analysis
Northern hemisphere	-	6-10 days (depending on availability of data)	Deutscher Wetterdienst (DWD), Offenbach, F.R. Germany	Numerical computer analysis
N-Atlantic	18°-70°N	6 hourly	Meteorol. Service, USSR, Moscow	Machine plotting, subjectively smoothed against climatological values
N-Atlantic	20°-70°N	12 hourly	Service Météorol. National, (SMN), Paris, France	Numerical computer analysis
N-Atlantic	70°W-40°E 30° -90°N	every 6 days	DWD, F.R. Germany	
Eastern N-Atlantic	20°W-0° 30° -55°N	daily	SMN, France	
Eastern N-Atlantic	40°W-10°E 42° -66°N	monthly	ICES, Copenhagen	Using average values calculated for 1° lat. - 2° long. squares
Eastern N-Atlantic	Waters east of France	half-weekly	SMN, France	
Eastern N-Atlantic	25°W-15°E 47° -70°N	every 5 days	Meteorol. Office, U.K.	Prepared for "waters surrounding the British Isles"
North Sea	-	every 5 days	Meteorol. Office, U.K.	

[1] This list is prepared on the basis of a collection of SST maps which was made available by the courtesy of Dr. E. Okada, Japan Fisheries Information Service Center.

[2] This office also prepares, on a routine basis, maps showing temperature anomalies, surface current streamlines, mixed layer depth forecast, and others.

Area	Geogr. Coordin.	Period	Office	Comment
North Sea	-	weekly	Deutsches Hydrograph. Inst. Hamburg, F.R. Germany	Manually plotted, giving higher weight to more recent observations; the same for temperature anomalies
North Sea	(incl. Eng. Channel)	weekly	Hydrograph. Office Royal Netherl. Navy	Manually plotted, considering climatological distribution
Baltic Sea	-	half-weekly	Swedish Meteorol. Institute	Manually plotted also using aircraft observations
Western N-Atlantic	95°-35°W 15°-50°N	weekly	Fleet Center, Norfolk	
Western N-Atlantic	71°-38°W 32°-50°N	weekly	Canadian Meteorol. Service, Halifax	Gulf Stream area; analysis taking into account previous distribution of water masses and seasonal trends
Western N-Atlantic	90°-30°W 25°-45°N	monthly	U.S. Naval Oceanogr. Office	Showing Gulf Stream position, especially its northern edge; similar charts are prepared for temperature anomalies and temperature changes against preceeding month
Waters off the U.S. Atlantic Coast	varying areas	daily	National Environ. Satellite Service	Using satellite data
	34°-38°N off Mass.	daily on request	U.S. Coast Guard Oceanogr. Unit	Airborne radiometer measurements. Maps also include visual sighting of fish schools and mammals
	Rhode Isl. off Cape Cod - Cape May	daily on request		
Hudson and Baffin Bay	-	every 5 days with daily updating	Meteorol. Office, U.K.	Prepared for sea ice forecasts
Pacific Ocean	15°-60°N	6 hourly	Meteorol. Service USSR, Vladivostok	
Tropical Pacif. Ocean	45°S-40°N	monthly	Far Seas Fisheries Research Laboratory, Shimizu, Japan	Prepared as part of a pilot project for tuna fishery

Area	Geogr. Coordin.	Period	Office	Comment
Eastern N-Pacific	175°-155°W 40°-55°N	monthly	Canadian Weather Service, Esquimalt	Observations averaged over 2° squares. Similar charts also for temperature anomalies
Eastern N-Pacific	170°-120°W 35°-60°N	half-weekly	Canadian Weather Service, Esquimalt	
Eastern N-Pacific	140°-80°W 5°-30°N	weekly	National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, Calif., U.S.A. (see part II, Evans, Laurs)	"Sea conditions analysis charts" also containing sea state forecasts - Produced for either northern, central or southern parts of the area according to likelihood of fishing grounds
Eastern N-Pacific	135°-115°W 23°-51°N	half-monthly	National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, Calif., U.S.A. (see part II, Evans, Laurs)	Fishing information - supplement
Waters off the U.S. Pacific coast	37.5 -40°N	daily on request	U.S. Coast Guard Oceanogr. Unit	Airborne radiometer measurements; maps also including visual sightings of fish schools and mammals
Western N-Pacific	125°-149°E 24°-38°N	12 hourly in April-June; every 5 days during other months	Japan Fisheries Inform. Service Center, Tokyo	Also containing information on currents and fisheries: for more information see part II
Western N-Pacific	110°-180°E 10°-53°N	every 10 days	Japan Meteorol. Agency, Tokyo	Manual plotting using average observations for 1° squares
Western N-Pacific	120°-180°E 15°-50°N	monthly	Japan Meteorol. Agency, Tokyo	
Japan adjacent seas	125°-150°E 25°-45°N	half-monthly	Hydrographic Office, Maritime Safety Agency, Japan	Charts also indicating surface currents and ice conditions

Area	Geogr. Coordin.	Period	Office	Comment
Japan adjacent seas	Off Kyushu and Honshu	half-monthly	Hydrographic Office, Maritime Safety Agency, Japan	
Japan adjacent seas	135°-143°E 30°-37°N	monthly	Tokai Laboratory, Japan	
Japan adjacent seas	limited area off Honshu	monthly	Aichi Prefect. Laboratory	
Japan adjacent seas	125°-150°E 25°-45°N	4 times/year	Hydrographic Office, Maritime Safety Agency, Japan	Chart showing the "state of adjacent seas of Japan" summarizing the various half-monthly maps
Western S-Pacific	140°-155°E 33°-45°S area Sydney-Adelaide	monthly	C.S.I.R.O., Division of Fisheries and Oceanogr., Cronulla, Sydney, Australia	Based on 1/4° square means calculated from ships' observations
Western S-Pacific	140°-180°E 25°-50°S	monthly	C.S.I.R.O., Division of Fisheries and Oceanogr., Cronulla, Sydney, Australia	Based on 1° square means calculated from routine ships' observations
Western S-Pacific	Off eastern coast of Australia	daily on request	C.S.I.R.O., Division of Fisheries and Oceanogr., Cronulla, Sydney, Australia	Airborne radiometer measurements, (see part II)
Western S-Pacific	140°E-160°W 25°-50°S	every 5 days	New Zealand Meteor. Service	Subjective analysis of about 100-200 observations based upon general studies on oceanic circulation, upwelling, etc. - similar maps are prepared for temperature anomalies
Western S-Pacific	Off east coast of North Isl. off west coast of S. Isl.	daily if needed for fisheries	New Zealand Oceanogr. Institute, Wellington	Airborne radiometer measurements; also showing limits of colour (green coastal water against blue offshore water)
Western S-Pacific	Off east coast of North Isl.	half-monthly	New Zealand Oceanogr. Institute, Wellington	Based on ships' observations

ENVIRONMENTAL ANALYSES IN MARINE FISHERIES RESEARCH - FISHERIES ENVIRONMENTAL SERVICES

PART II: FISHERIES ENVIRONMENTAL SERVICES

1. INTRODUCTION

In this part II fisheries environmental services established to assist various national fisheries are described by scientists responsible for their organization.

The descriptions of the services established for the French albacore fishery in the North Atlantic Ocean and in Japan are prepared by the editor, based on information made available by the services. The editor wishes to acknowledge with appreciation the information received from Dr. P. de la Cochetière (Meteorological Service, Boulogne), Dr. H. Aloncle (ISTPM, Nantes) and Dr. P.M. Vitureau (CNEXO, Paris) concerning the French service for the albacore fishery in the North Atlantic Ocean, and to Dr. E. Okada, Director, Japan Fisheries Information Service Center (JFIC), Tokyo. Mr. Okada and staff members of the JFIC - on the occasion of a visit of the editor to the Center - gave details of the organization and the duties of the Center which supports the various Japanese fisheries in the seas adjacent to Japan and in the northern Pacific Ocean and which also kindly provided the maps reproduced in Chapter II, 5.

The editor also wishes to thank Drs. T. Hirano (University of Tokyo) and I. Yamanaka (Far Seas Fisheries Research Laboratory, Shimizu) for additional scientific information and, especially, Dr. A. Tomosada (Tokai Regional Fisheries Research Laboratory, Tokyo) for his manifold assistance in preparing English translations from the Japanese texts.

2. SEA SURFACE TEMPERATURE MAPS TO ASSIST TUNA FISHERIES OFF NEW SOUTH WALES, AUSTRALIA

by

K.F. Williams[1]

2.1 Introduction

Southern Bluefin tuna Thunnus maccoyii enter the fishing area (N.S.W. south coast) in August/September. At this time the fish are migrating northward in the inner coastal waters and are the subject of some fishing pressure from a relatively small troll fishing fleet. The fish continue the northward migration until encountering water of a preferred temperature (approx. > 17°C and < 20°C). When in these preferred temperature areas the fish form rippling schools - in this behavioural phase the fish are susceptible to capture by the live bait and pole method of fishing (and to purse-seining) which is the method used by most Australian tuna fishermen.

The fish do not form rippling schools below about 17°C and in schools above about 21°C the fish do not bite very well. Other types of schools, e.g., feeding schools, are not as susceptible to live bait and pole fishing (or purse-seining) as the fish tend to be more dispersed and cannot be 'chummed' into a feeding frenzy.

Within this preferred temperature range the fish show a tendency to congregate around areas where there is a large temperature change (usually > 1°C and sometimes up to > 4°C) over a short horizontal distance - a temperature 'front'. Sometimes these 'fronts' are visible to the naked eye, however most of the time are only detected by thermograph monitoring on the vessel. The visible fronts are usually characterized by a distinct water colour change on either side of a line of scum, foam etc., on the surface.

The basic aims of tuna fishing off New South Wales are to find (a) waters within the preferred temperature range and (b) fronts within these waters.

2.2 Basic idea of the SST map service

The CSIRO service (Division of Fisheries and Oceanography) not only facilitates boat searching but also allows the spotter aircraft to search only areas that have a chance of being productive. Previously the spotter aircraft (at present up to 6 planes) had no way of knowing the surface temperature without a surface vessel to inform him. Thus when searching was carried out in areas with no fishing boats, e.g., start of season surveys, the entire time could have been wasted by searching in areas of unsuitable temperatures.

Thus the service is of immediate benefit in allowing the fleet and aircraft to search only potentially productive areas. Also the maps have encouraged the fleet to expand their efforts geographically. The fishermen now tend to go further to sea knowing that some favourable 'fronts' (indicated by the maps) exist there. Previously, before about 1968, the fishery was restricted to areas near the continental shelf; now, 1977, the fishery extends up to 200 miles seaward.

[1] This description is an update of the papers by J.S. Hynd (1968, 1969) as the technique has not undergone any major changes since then. In fact for some of the more recent surveys (although a new machine has been purchased) the same instrument has been used as in the 1968 surveys.

This expansion of fishing area probably allows fewer fish to be 'missed' during the season and certainly assists in the catches of older fish in years when the smaller fish are not present in large numbers. This occurred in the 1973-74 season (Hynd, 1974).

The SST maps will also show (Hynd, 1968) when and where the tuna season is likely to begin. This can allow strategic positioning of the fleet and spotter aircraft in advance. Also back-up shore facilities (unloading capabilities, trucks, ice, personnel, etc.), can be arranged in advance. Also the maps will indicate when and, now, where the season will end. Now the boats sometimes fish as far south as the central coast of Tasmania. Previously the season was considered to be finished when the 20°C isotherm passed Gabo Island. The advent of sea surface temperature measuring and map production from satellites has, however, diminished the value of the SST surveys for these two general objectives. But the usefulness of the satellite maps is also restricted to these general levels.

As the maps cannot be produced continuously (cost barrier) they can be used to gain information between the times when maps are available. This can be done on the basis that the warm water (during the season) has a general southward movement (East Australian Current).

2.3 Environmental product preparation

The temperature of the water is measured using an airborne infra-red radiation thermometer. The instrument picks up radiation in the infra-red and compares this radiation with that coming from a body of known temperature. This allows the temperature of (in this case) the water to be evaluated. The calibration techniques (Hynd, 1968, 1969) allow the temperature to be calculated to within ± 0.5°C (at the worst). Ground truth checks within the best year have always been within ± 0.2°C when a reliable ground source was used - research personnel and accurate thermometers.

Flights off the N.S.W. coast are planned to go up to 180 nm east with flight paths every 0.5° of latitude apart (i.e. 30 nm); maps 1-14 (sub-section 2.5.1) show general flight paths. Thirty miles is as far apart as practicality will allow and anything much less results in the map not being produced in real time. The maps, thus, are produced in approximately 2-3 days (depending on the extent of the preferred temperature range), excluding breakdowns, bad weather etc.

Hence actual known temperatures only occur on the flight paths which are 30 miles apart. On these tracks the whole degrees of temperature are plotted, i.e., when the trace of the radiometer printout crosses a whole degree of temperature this is plotted on the aircraft flight path over the water. This is done by the proportional division of the strip chart recorder printout and the aircraft track over the water. Thus positions, where the water temperature crosses over whole degrees, are plotted on the chart of the ocean.

Isotherms are drawn by joining points of equal temperature - whole degrees only although it would be possible to draw half degrees as well. Half degrees would be impractical because of the relatively small area covered, i.e., the plotting of whole and half degrees would result in a map overcrowded with isotherms and unreadable.

The areas between the flight paths may be expected to have temperatures different to those shown on the map occasionally. This is because some smoothing must occur when joining points of equal temperatures 30 miles apart. However, practicality precludes tracks too much closer together being flown, as mentioned earlier. This smoothing will occur in any similar type of production, e.g., isobar map of the atmosphere - and the errors in this system are probably quite small (e.g., see map 1, 24 and 25 July 1973, where surface temperatures are available from a merchant vessel). Over the past few years these sort of checks have been available occasionally and the maps have always been quite accurate.

The plotting of degrees of whole temperature etc., usually takes place on board the aircraft. Also while on board the temperature fronts are noted. These are detected instantaneously by the instrument and noted immediately, logging also whether they were visible to the naked eye or not.

Immediately after landing these notations and positions of whole degrees of temperature are traced onto fresh blank charts. On this chart the actual isotherms and any other salient points are drawn and noted.

2.4 Period of service

The period covered by the SST maps should ideally be just before the tuna season starts, or is due to start, till the end. Knowing when it will start however depends on the maps themselves - so it is usual to fly the first map at approximately the end of July. This is well before the tuna season usually gets underway and allows predictions (from this and the next maps) as to geographical position of start of season and time of start (as mentioned earlier).

In recent years maps have been produced on a fortnightly basis. This has seemed to be quite acceptable to everyone concerned. Ideally perhaps on a weekly basis would be slightly preferable particularly in bad seasons or when conditions undergo a dramatic change in a short period; however this has its practical limitations in as much as the aircraft is almost constantly flying. This leaves little time for maintenance of the electronic gear or the aircraft itself and requires several extra personnel both for work in the aircraft and for assistance in the 'on ground' activities.

2.5 Distribution and interpretation of maps

The maps are of greatest benefit when delivered to the fishermen, spotters, etc., instantly. This is what we endeavour to do. Immediately the aircraft lands, having finished all the flight legs, a final copy of the map is drafted. This final draft is copied on a copying machine, carried in a car that meets the aircraft at whatever airport has been designated. The maps are then delivered first to the fish spotters and their pilots (who are usually on hand anyway) and then to the fishermen at whatever ports they are in at the time. These ports can stretch from Eden to Sydney (approximately 300 miles). However all interested parties usually have the maps within 8-10 hours of completion of the flying. Extra copies are deposited at the various fishermen's cooperatives in each port for the fishermen who are at sea during the distribution.

The basic level of interpretation is the one carried out by fishermen, spotters and scientists to find the areas most favourable for the occurrence of rippling schools of tuna. This involves studying the map and locating areas with surface temperatures between 17° and 20°C and then seeing if any suitable 'fronts' exist in these areas. These would be the positions the fishermen and spotters would examine first. Thus any favourable areas are not likely to be missed, which certainly happened before the maps were thought of and any favourable areas more than about 50 miles to seaward were nearly always missed.

Even if no fronts are seen in the preferred temperature range the maps at least ensure that searching is carried out in the right area.

Another level of interpretation is slightly more involved. This requires some knowledge of the movements of the East Australian Current. This current moves southward down the N.S.W. coast. It can be seen as a series of pools (eddies) of water, each pool warmer than the preceding one. Temperature fronts are seen at the edges of pools. Thus a series of fronts pass down the coast - each one warmer than the previous one (Hamon, 1965). This can allow predictions of the general isotherm change in the periods between maps. The general southward movement of isotherms can be seen in the attached charts (maps 1-14). The ability to be able to predict movements of the 20°C or 21°C isotherm can be of use in foretelling the northern limit of fishing and the end of the season, i.e. when the 21°C isotherm is well to the south in Bass Strait.

2.5.1 Analysis of examples

Maps 1-11 show a series of SST charts from July to December 1973 at approximately fortnightly intervals. It is possible to follow the passage of the 20°C isotherm down the coast from October to December. This is the typical sort of situation on this coast although in this particular season the traverse of the 20°C isotherm started further south than usual and hence made conditions unsuitable for the catching of bluefin during much of the 'usual' time (see Hynd, 1974).

For the interpretation of the maps look at maps 9 and 10. At the first level - from map 9 - all searching would be restricted to areas south of Eden - except for a little inshore water to the north and some well offshore water which is > 19°C anyway. In the areas south of Eden the most favourable areas would be the two 'fronts' to the east of Gabo I. There may have been other 'fronts' in the area but if there was the aircraft did not fly over them.

The next map (map 10) was put out on December 4, i.e. 3 weeks later. Since map 9 would not be 'current' at that time some predictions would have had to be made as to the positions of isotherms before map 10 was produced if map 9 is to be fully utilized. With the knowledge of the East Australian Current that is available (as explained earlier) it would have been predicted that by the time of map 10 the 20°C isotherm would have been further south. This is in fact what happened and the 20°C isotherm extended into Bass Strait i.e. south of 37°30'.

To further study this second level of interpretation look at map 4. One of the main features of this map is a large pool (eddy) of water > 19°C with many temperature fronts associated with or near its boundaries. The southern extremity of this pool is approximately 35°30'S (just south of Jervis Bay). At the time of map 7, October 12, the southern extremity is past 37° south. Maps 9 and 10 show bodies of water of higher temperature with fronts near the boundaries moving progressively down the coast.

Maps 12-14 document some of the catches of bluefin that were made as a direct result of the isotherm maps in the 1974 season. In map 13 it can be seen that there is a large pool (eddy) of water > 19°C with fronts at its boundaries. At these southern fronts fish were caught two days after the map was produced indicating perhaps that fish may be 'pushed' south by the fronts associated with these eddies as suggested by Hynd (1968).

2.6 Service effectiveness

Financial benefits are impossible to quantify but are obvious and at least substantial. These have become more apparent to fishermen in the 1975-76 and 1976-77 seasons. Over these last two seasons overheads (particularly fuel) have risen alarmingly and the fishermen have not been able to do the searching of previous years. This had led them to rely more on the isotherm maps and searching by the spotter aircraft making use of the SST maps. This was made more important by very poor catches in these years (particularly 1976-77).

These last two seasons apart (when the maps were more value) the fishermen have considered that the maps gave a considerable reduction in steaming time as well as an increased catch. Considering that each map can be produced for less than $2000, an increase in catch of only 5 tons of fish would be enough to pay for it. On several occasions we know that particular maps have been directly responsible for catches of 200-300 tons, so the cost benefit is obvious.

2.7 References

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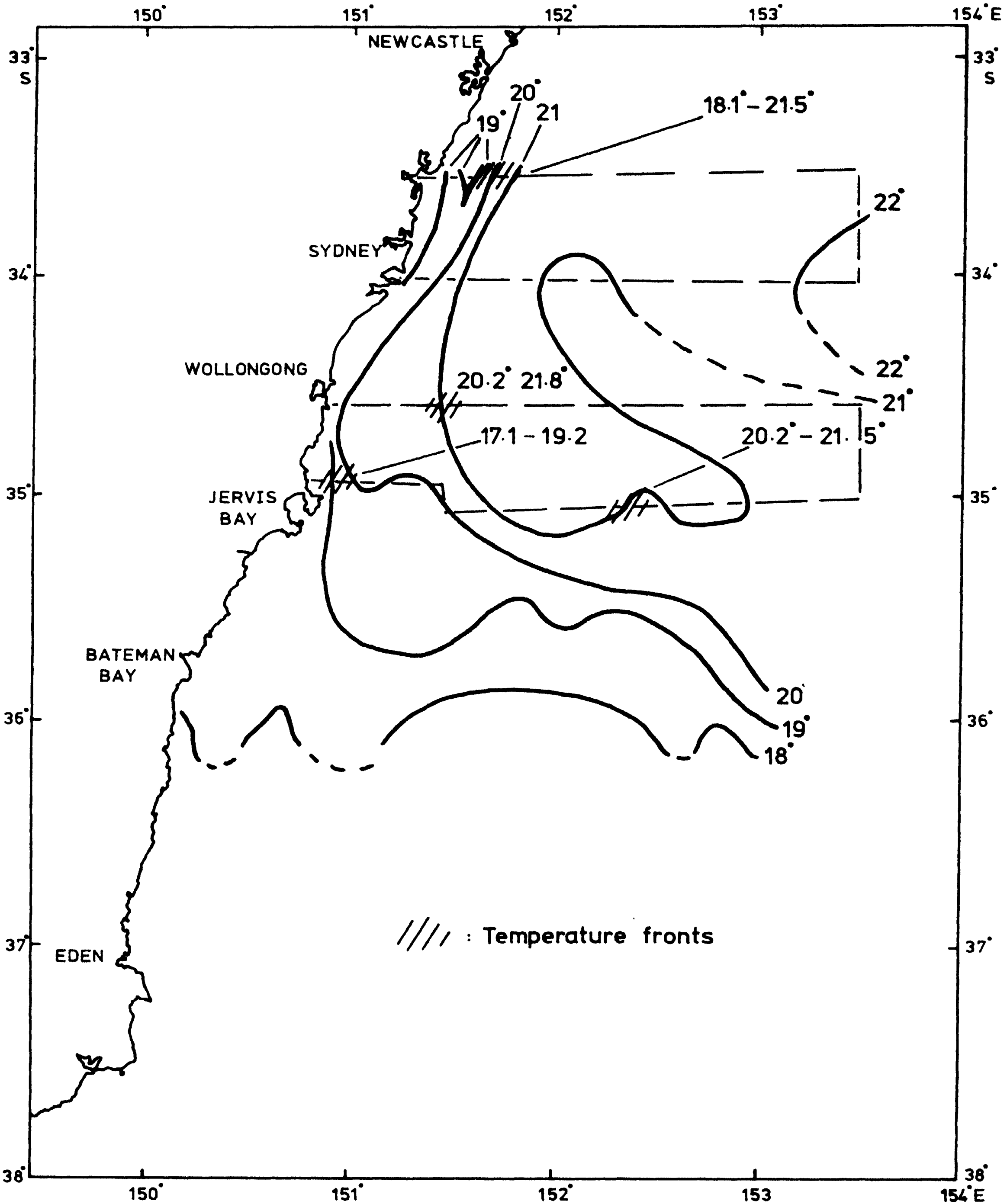
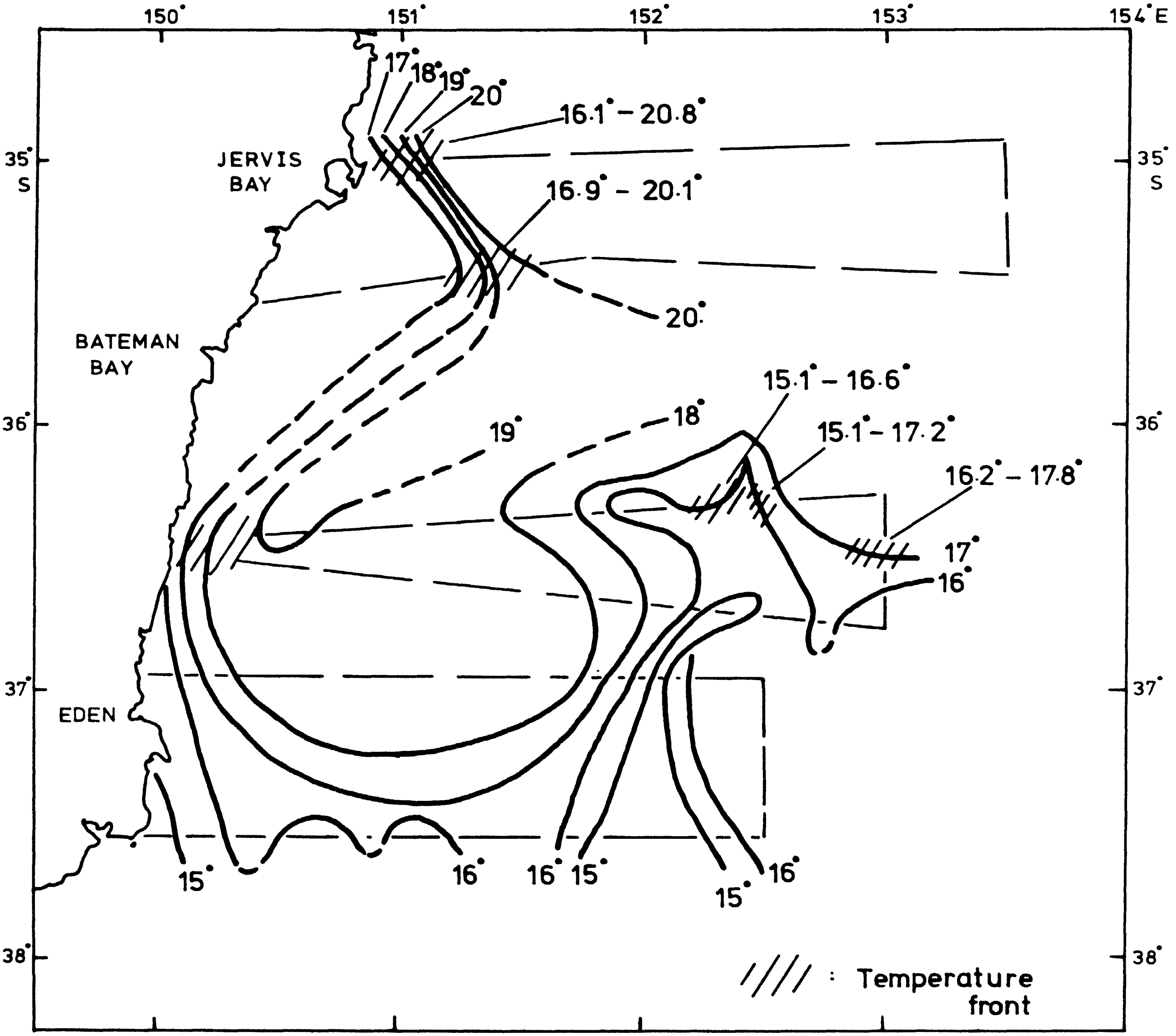


1. Aircraft flight paths and surface isotherms (°C) 24.25/07/73.



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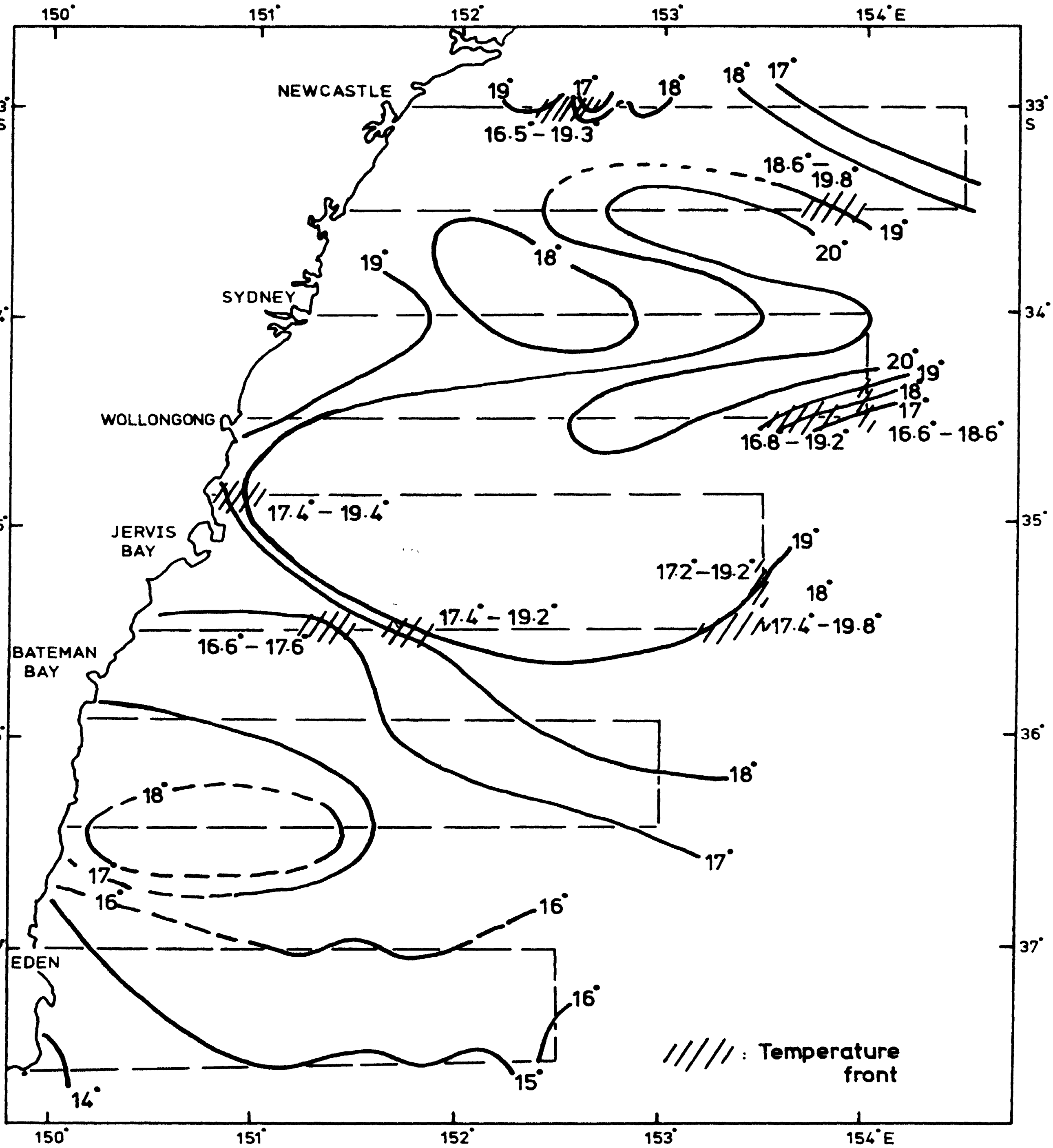
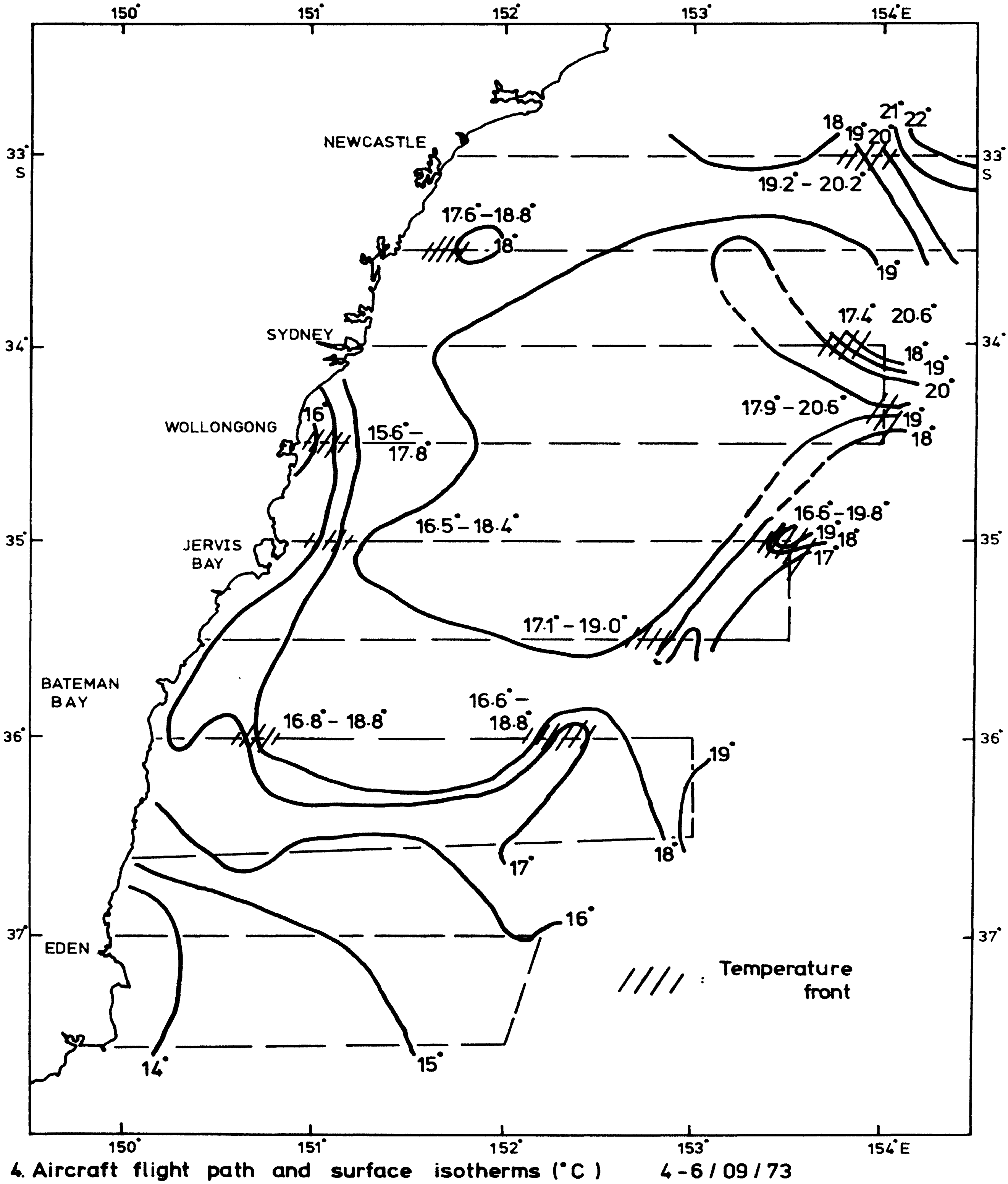
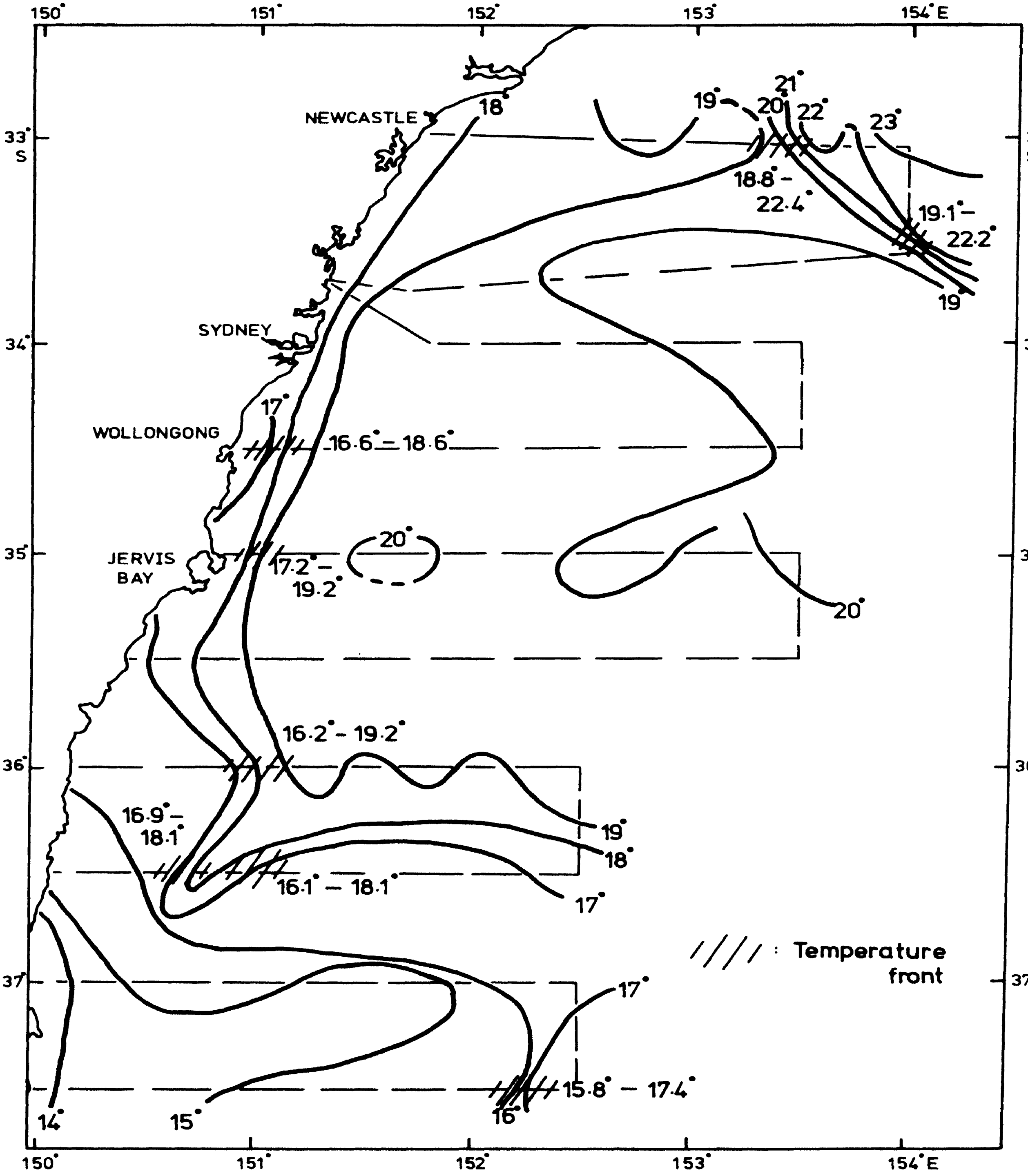


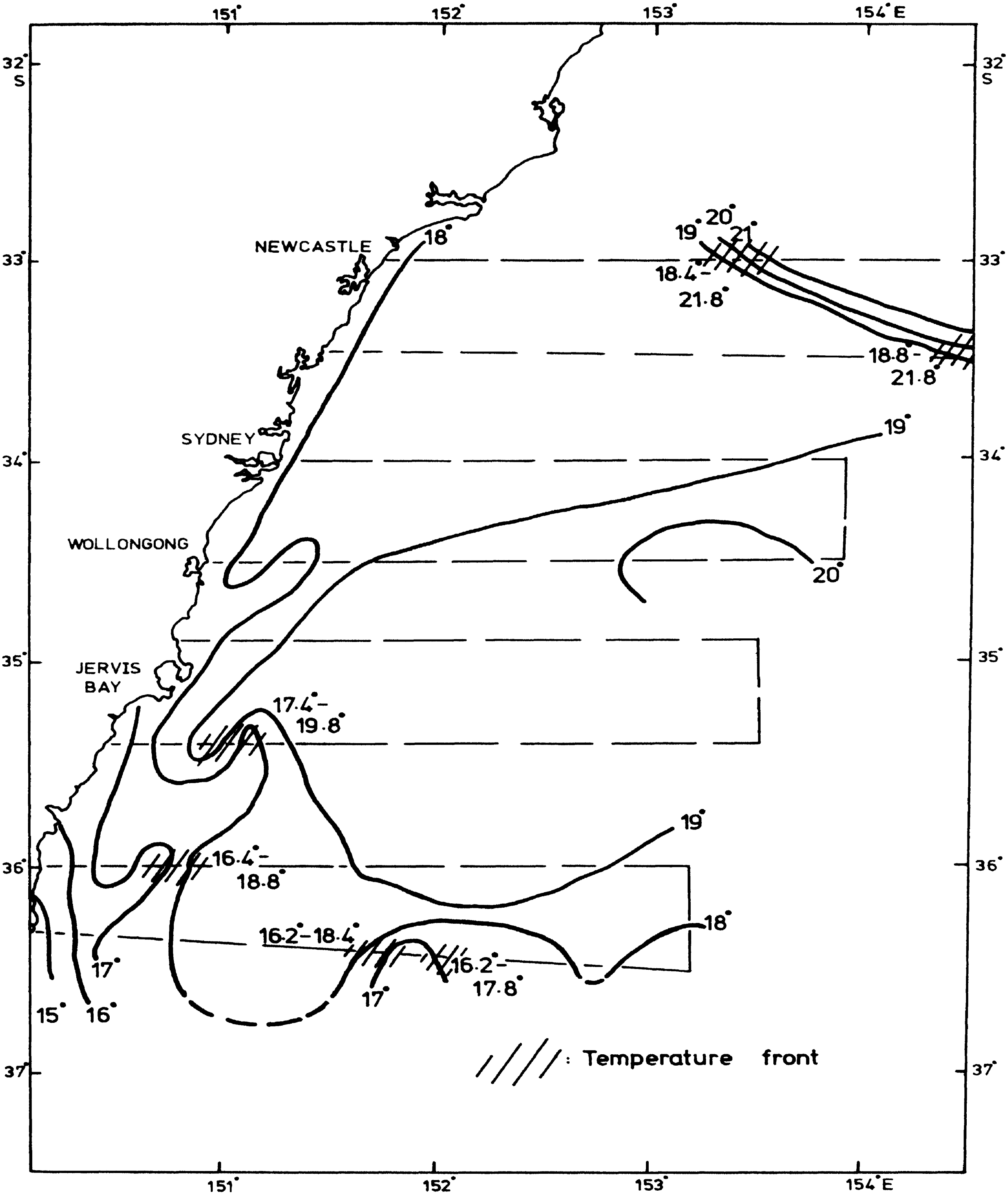
3. Aircraft flight path and surface isotherms (°C) 21-23/08/73



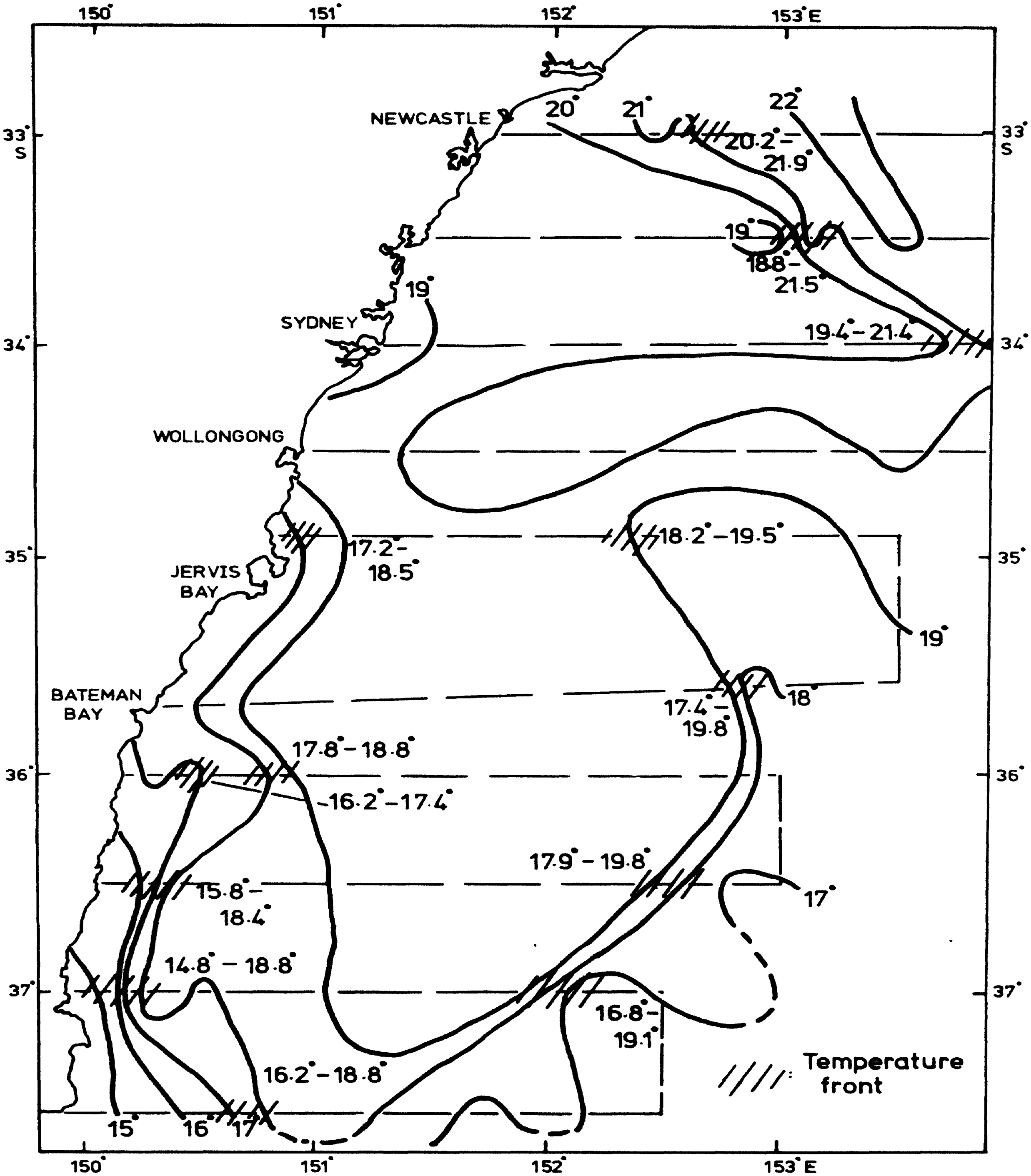
4. Aircraft flight path and surface isotherms (°C) 4-6/09/73



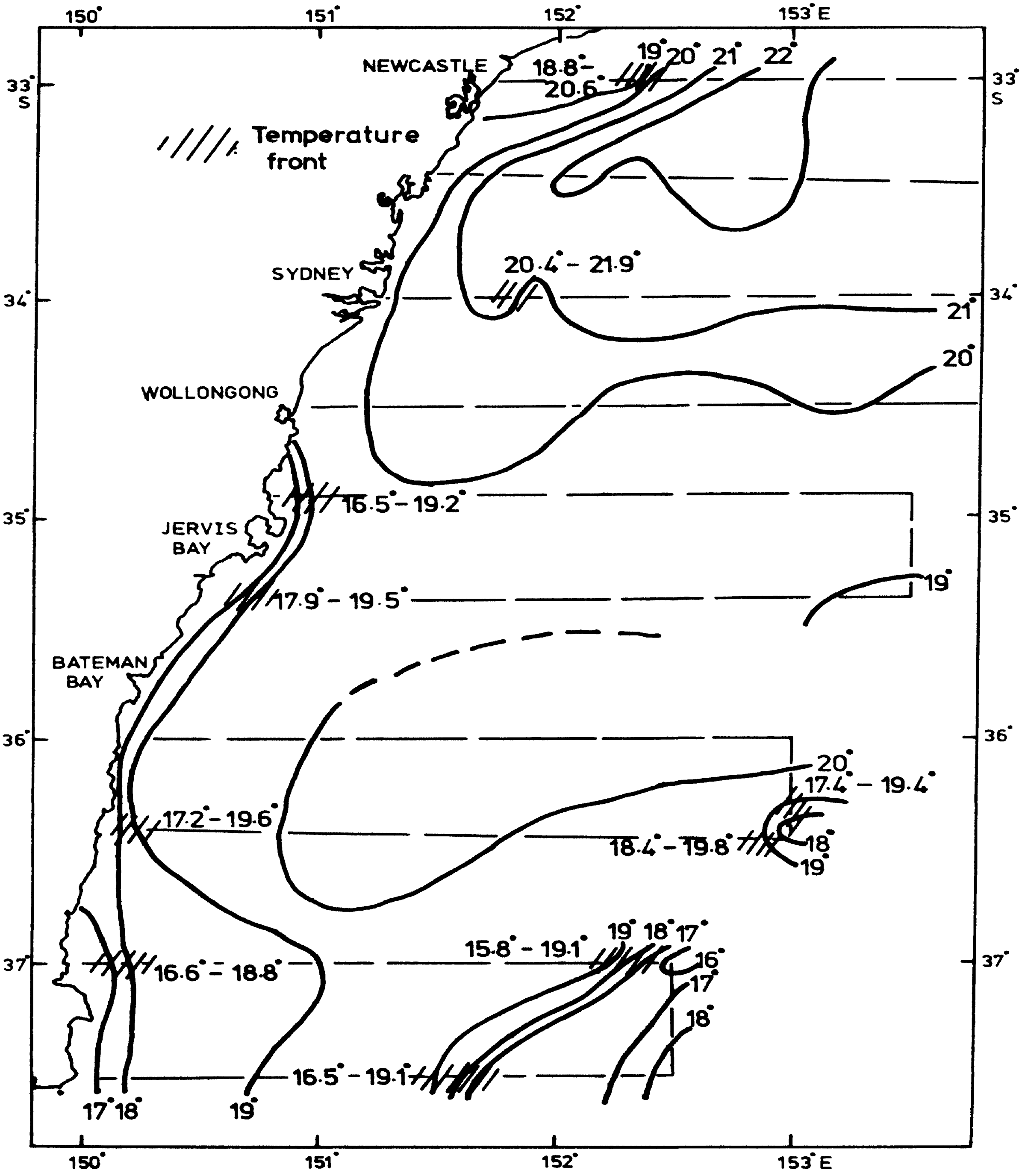
5. Aircraft flight path and surface isotherms (°C) 19-20/09/73



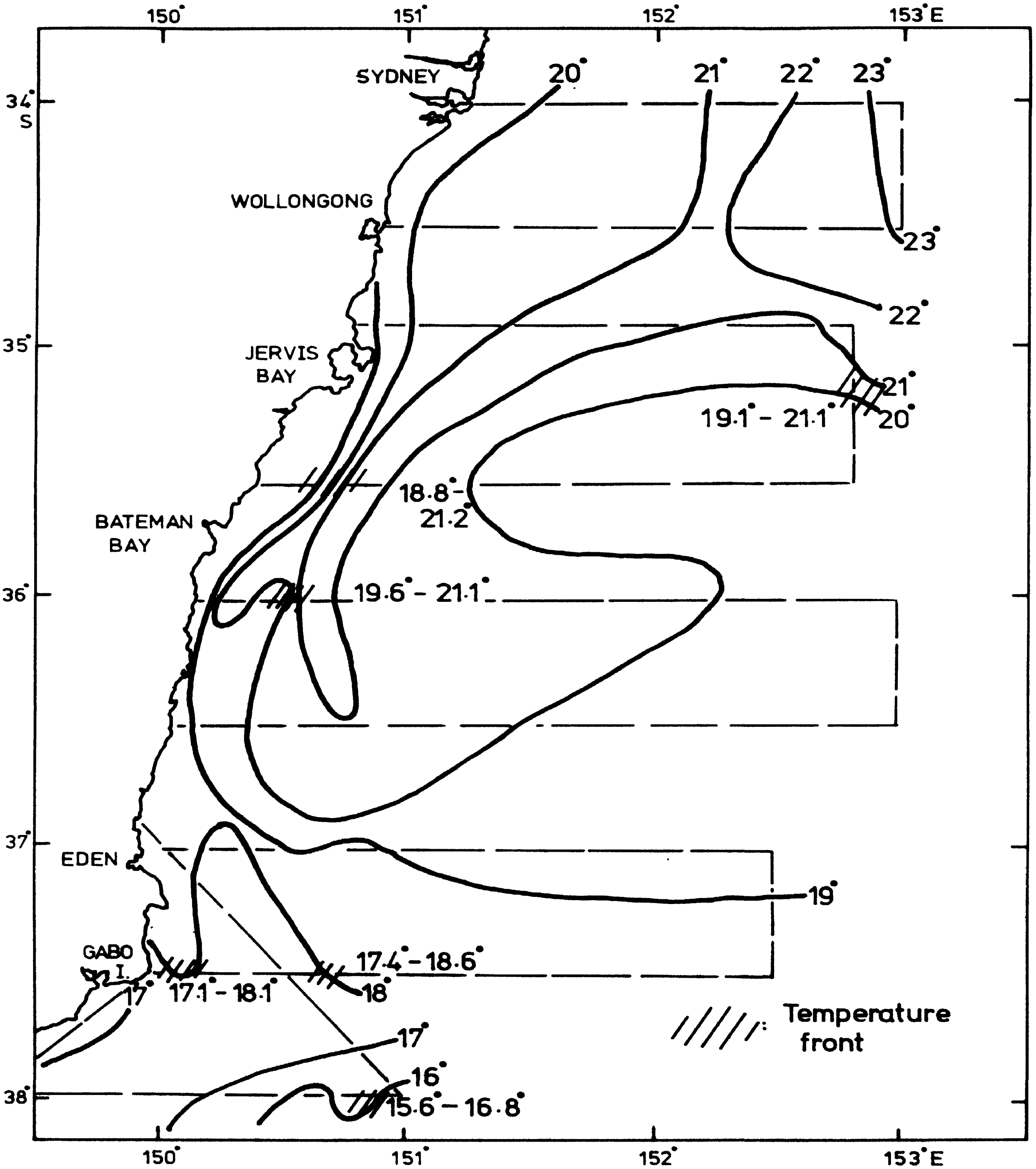
6. Aircraft flight path and surface isotherms (°C) 2-5 / 10 / 73



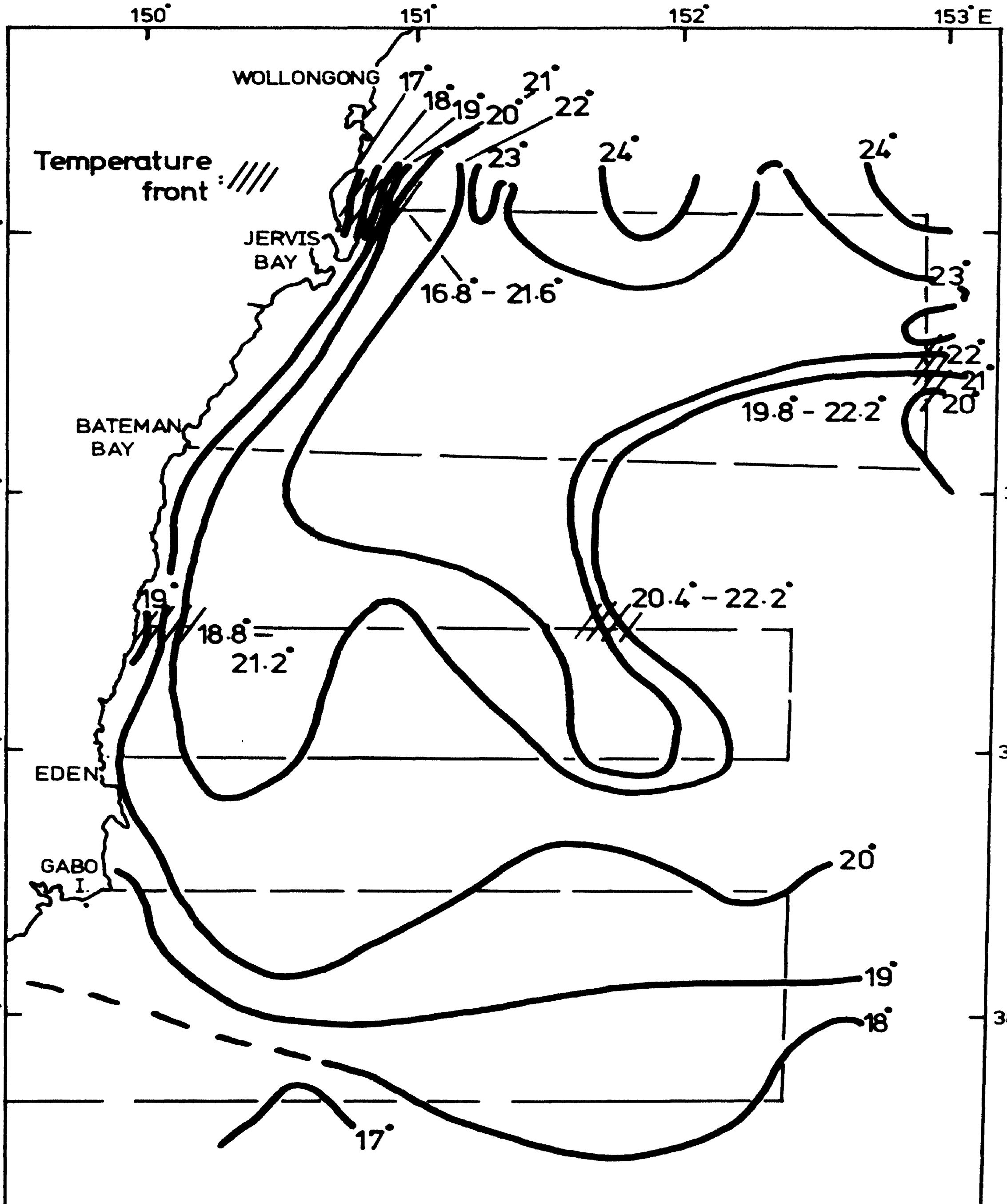
7. Aircraft flight path and surface isotherms (°C) 15-17/10/73



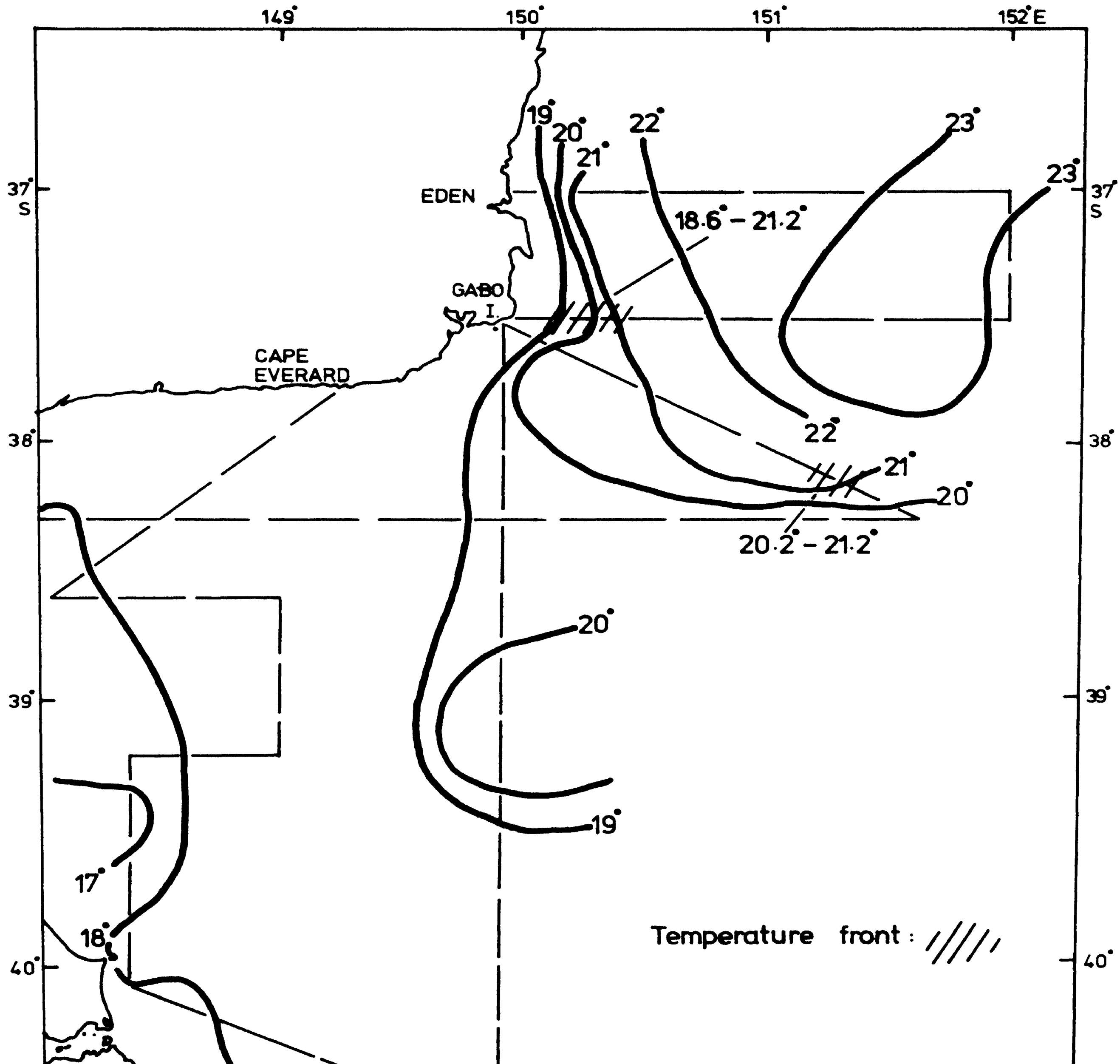
8. Aircraft flight path and surface isotherms (°C) 29-31/10/73



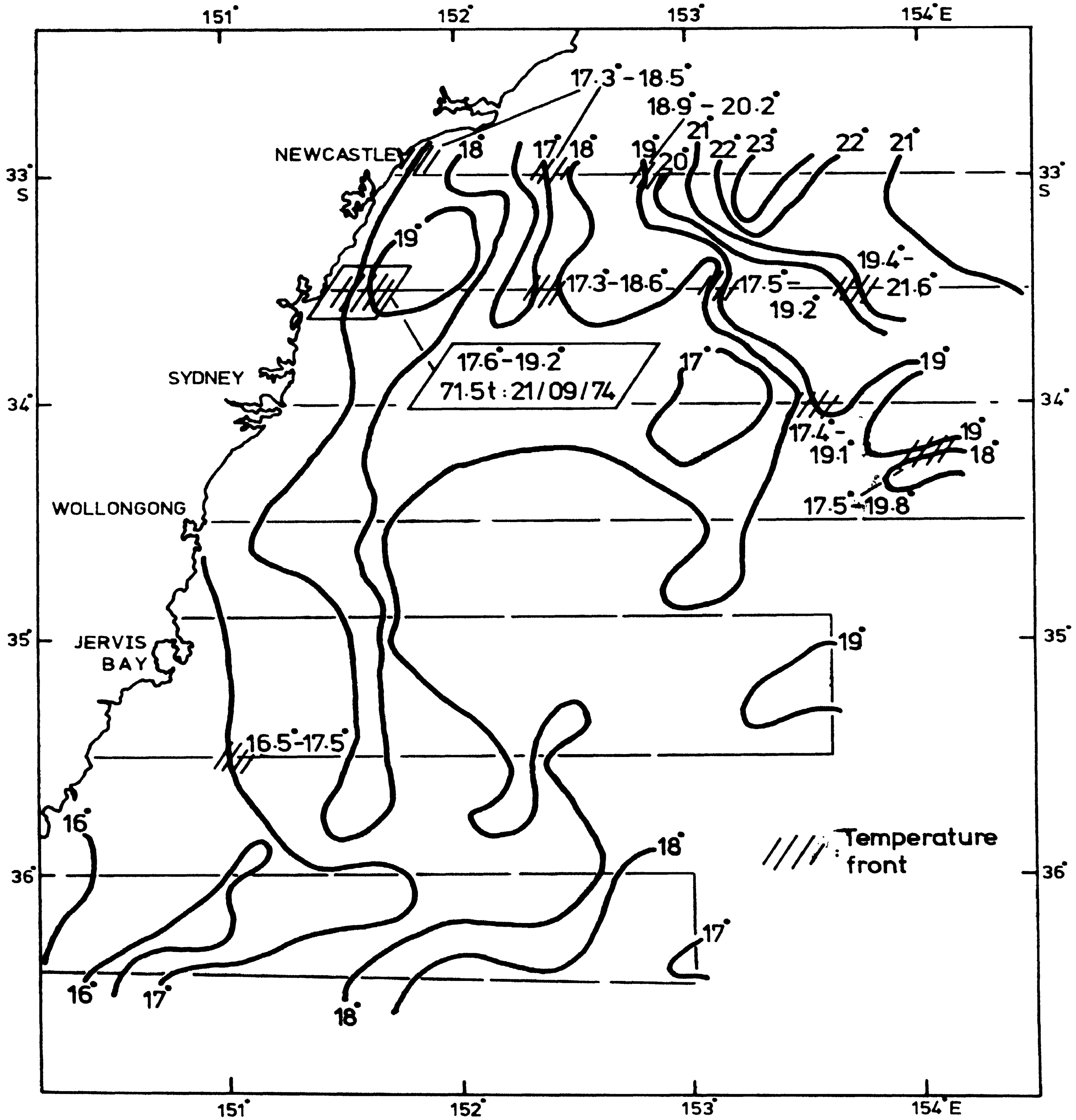
9. Aircraft flight path and surface isotherms (°C) 12–13/11/73



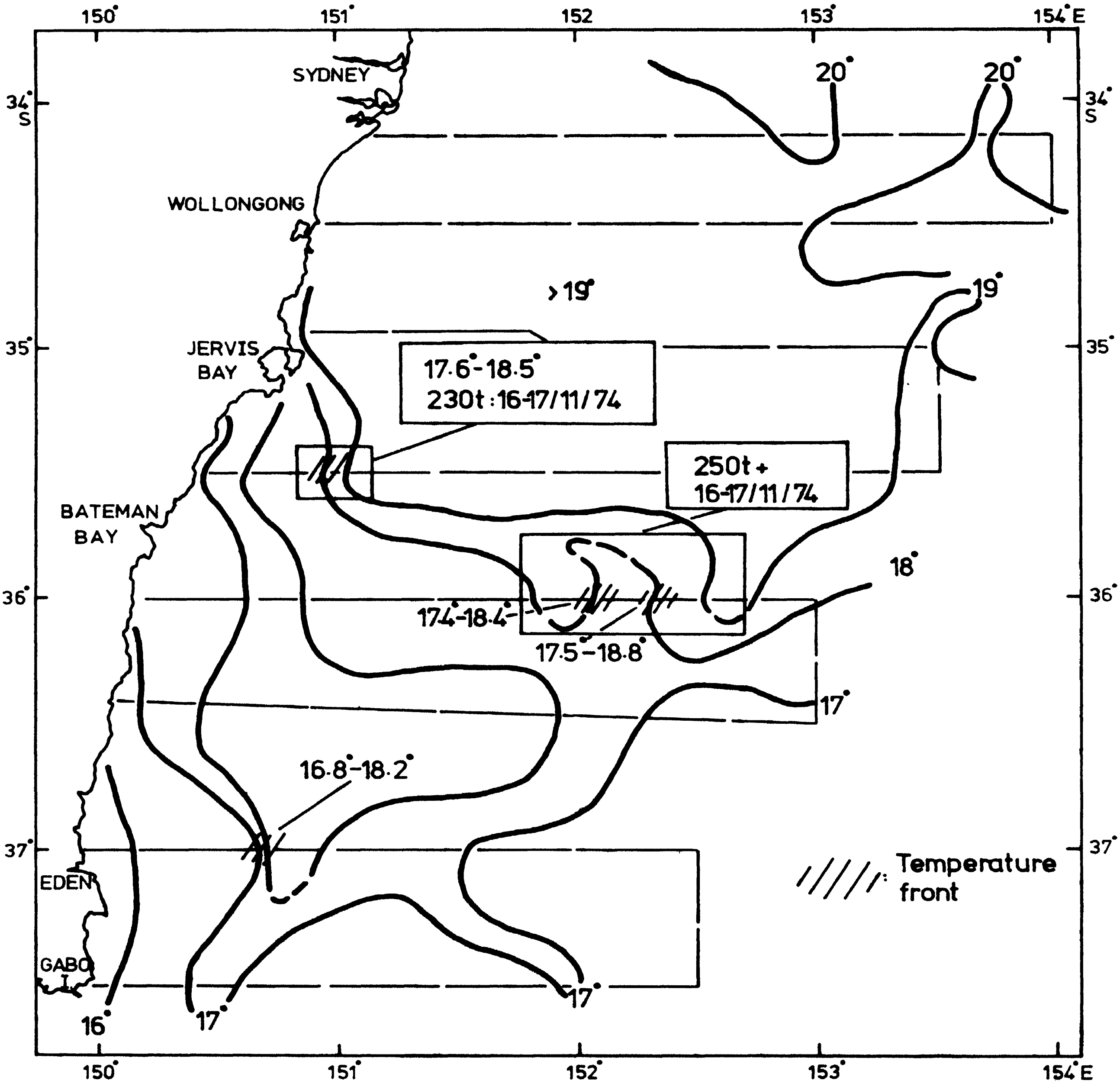
10. Aircraft flight path and surface isotherms (°C). 3-4/12/73



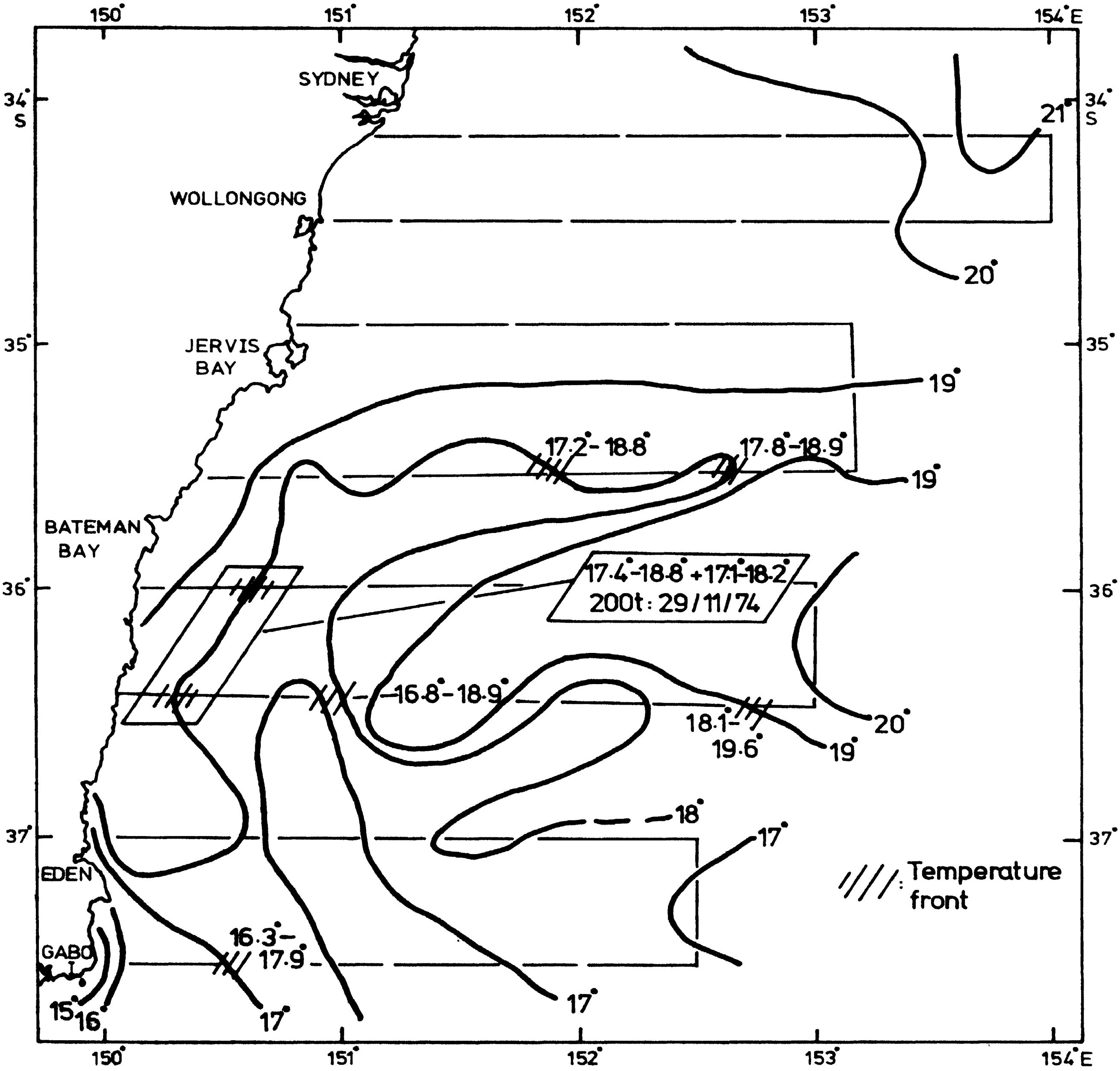
11. Aircraft flight path and surface isotherms (°C). 17-18/12/73



12. Aircraft flight paths and surface isotherms (°C), with tonnages and dates of Bluefin Tuna catches. 18-19/09/74



13. Aircraft flight path and surface isotherms (°C), with tonnages and dates of Bluefin Tuna catches. 12-14/11/74



14. Aircraft flight path and surface isotherms (°C), with tonnages and dates of Bluefin Tuna catches. 26-28/11/74

3. ENVIRONMENTAL ADVICE TO FRENCH ALBACORE FISHERY IN THE NORTH ATLANTIC OCEAN

by

G.H. Tomczak [1/]

3.1 Introduction

In 1970 a programme was started in France aimed at assisting the albacore fishery in the North Atlantic Ocean by providing environmental analyses. Besides providing weather and sea state forecasts with a view to protecting fishing vessels from heavy weather and supporting fishing operations, oceanographic analyses are prepared for better location of fish aggregation and thus to help fishermen to save searching time.

The oceanographic advice makes use of sea surface temperature charts which are specifically prepared for this purpose in "real-time", i.e. using most actual observations made by auxiliary ships and particularly by the fishermen themselves in the area.

The first investigations in France on the behaviour of fish in regard to environmental effects, especially those of water temperature, had already been carried out some fifty years ago when it was found that demersal fish, such as cod, prefer a specific water temperature allowing only slight deviations. Later it was found that pelagic fish, such as tuna and swordfish also prefer water masses of specific temperature; they can tolerate however a somewhat wider range of temperature (about 3°-8°C).

Experience has shown that albacore in the North Atlantic seem to prefer temperatures between 17° and 19°C, but tolerate only relatively slight variations above and below this range (Figure 1). Within these limits, the most favourable conditions are found in so-called "thermal fronts", i.e. in areas with a strong horizontal temperature gradient.

3.2 Concerted action in establishing an environmental service

The environmental advice to the albacore fishery in the North Atlantic Ocean is provided through joint action by the Météorologie Nationale Française, Paris, the Institut Scientifique et Technique des Pêches Maritimes (ISTPM), Nantes, and the Centre National pour l'Exploitation des Océans (CNEXO), Brest. Fishermen contribute actively by providing temperature observations in the fishing area and - what seems important if any cost-benefit considerations are taken into account - by bearing the costs of chartering an auxiliary vessel for the fishing season. The season generally starts at the end of May/beginning of June and ends about the middle of October. During this period the area of fishing shifts slowly from the north of the Azores to 25°W to south of Ireland and the Bay of Biscay.

Figure 2 shows schematically the established collaboration between the various types of vessels - research vessel (ISTPM), auxiliary vessel (CNEXO), fishing vessels (up to about 300), weathership - and the contribution made by the French Meteorological Service. The scheme indicates which data are transmitted (meteorological, sea surface and subsurface temperatures) and which products are submitted to users. Most data and products are circulated by broadcast or radiotelephone, whereby isotherms are fixed by geographical coordinates. In some cases, especially between the National Meteorological Service and the auxiliary vessel the facsimile system is used for transmission of charts.

[1/] See acknowledgements, page 37

3.3 Duties of service's contributors

The responsibilities of the various institutes and organizations within the established system are as follows:

3.3.1 Institut Scientifique et Technique des Pêches Maritimes (ISTPM), Nantes

The institute is responsible for an oceanographic and fishery survey in the area which is generally started some time before the opening of the fishery season. The survey is executed by a Research Vessel of the institute; in 1976 this was carried out from May to August by the R/V "La Pélagia" in two phases; the first covering the sector north of the Azores to 30°W, the second the waters off the Iberian peninsula. The Research Vessel was assisted by some other vessels in order to cover a larger area within a certain time period. Oceanographers and fishery biologists aboard the Research Vessel prepare twice daily, a bulletin (P-2, figure 2) on the oceanographic and fishery situation which is broadcast in the forenoon and at night.

3.3.2 Centre National pour l'Exploitation des Océans (CNEXO), Brest

The organization is responsible for the investigations executed by an auxiliary vessel which is chartered by the fishermen for the period of the fishing season and follows the fishing fleet continuously to provide technical assistance, if needed. Environmental measurements on board the auxiliary vessel are made by a meteorologist from the French Meteorological Service, who is responsible for the daily Meteorological Bulletin (P-3, figure 2) and two biological oceanographers from CNEXO. The latter are gathering data on the albacore stock which are used for a fishery forecast for the following year and for better determination of the exploitable stock. They also prepare a fishery bulletin (P-3, figure 2) which is broadcast daily immediately following the Meteorological Bulletin and which, inter alia, contains a forecast of the oceanographic situation 24 hours later to provide some idea where albacore would most probably be found at that time. For the description of the sea surface temperature the SST chart prepared by the National Meteorological Service for the North Atlantic Ocean (P-1, figure 2) is taken as a basis whereby observations from fishing vessels equipped with a thermograph are used to define the most actual state. In view of the fact that there are sometimes more than 300 vessels in the area these actual observations contribute considerably to the exact positioning of the isotherms.

3.3.3 Météorologie Nationale Française, Paris

The service supports the fishing activities in the North Atlantic Ocean by providing charts which show, as already pointed out under 3.3.2, the sea surface temperature (Figure 3) and the sea state (Figure 4). In order to assist fishermen in decision-making on their fishing activity the charts on the actual wave heights, periods and directions are supplemented by charts forecasting the sea state 24 and 36 hours in advance.

3.4 Additional products - further development

Besides the SST chart for the whole North Atlantic Ocean (P-1, figure 2) broadcast by facsimile to the auxiliary vessel for further distribution to the fishing fleet, the Meteorological Service prepares biweekly another SST chart which refers only to the actual fishing area covering successively the areas from north of the Azores at the beginning of the fishing season to south of Ireland and the Bay of Biscay at the end of the season. This chart (P-4, figure 2) is mailed to a central fishery committee (Comité central des pêches maritimes, CCPM) which forwards it to interested users and to offices in the tuna fishing-harbours.

For some years CNEXO has also been trying to use satellite observations. Pilot experiments made for the more limited areas of the Bay of Biscay and adjacent waters are not yet satisfactory. However, with the experience gained from successful experiments in the equatorial region of the Atlantic Ocean, better results may also be achieved for the albacore fishery in the North Atlantic Ocean. It should be pointed out in particular that the experiments carried out by CNEXO are not only confined to satellite sea surface temperature observations but will very probably be extended to observations of the chlorophyll content of surface waters.

The service established in 1970 as a pilot programme has proved effective in locating the most profitable fishing grounds. It is therefore being continued on a routine basis.

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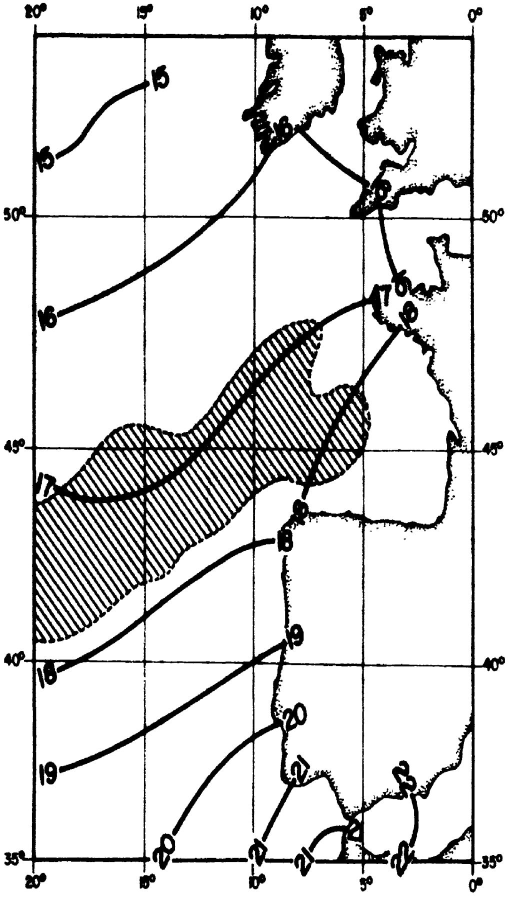

Figure 1:

Sea surface temperature distribution during the period 10-20 July 1971 also showing the zone of greatest catch rates (hatched area) (Document Météorologie française)

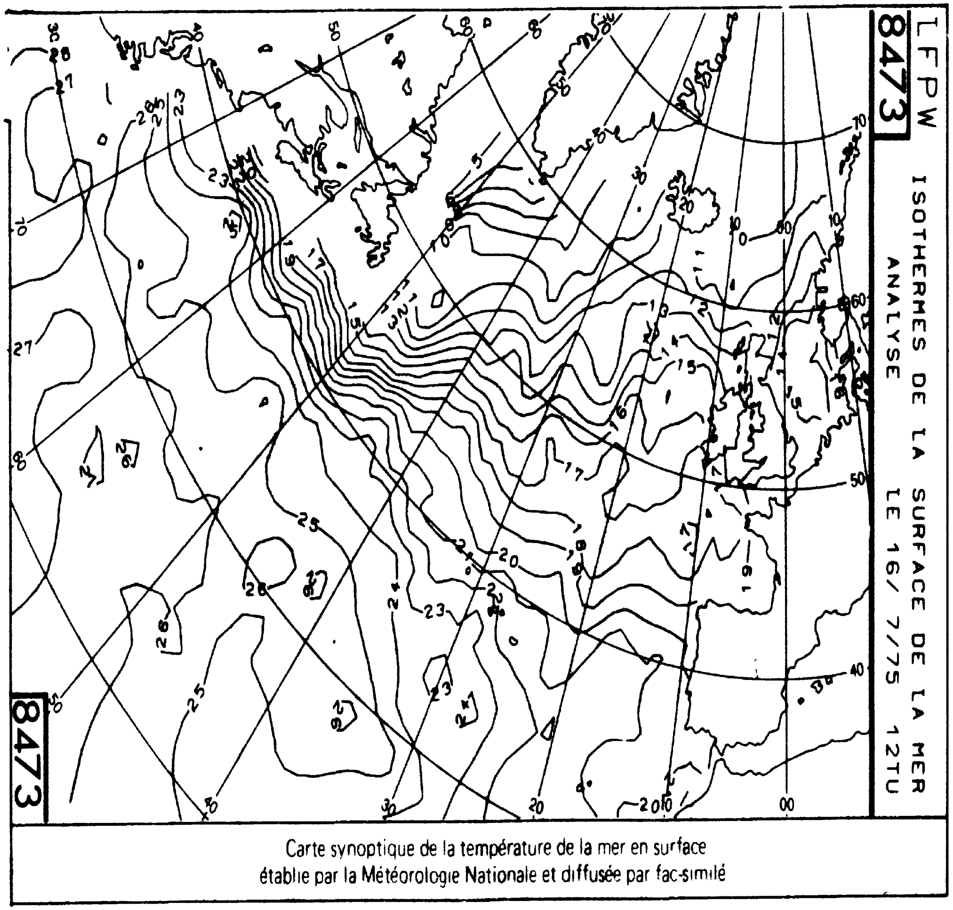
LFPW
8473
ISOTHERMES DE LA SURFACE DE LA MER
ANALYSE LE 16/ 7/75 12TU
8473
Carte synoptique de la température de la mer en surface
établie par la Météorologie Nationale et diffusée par fac-similé
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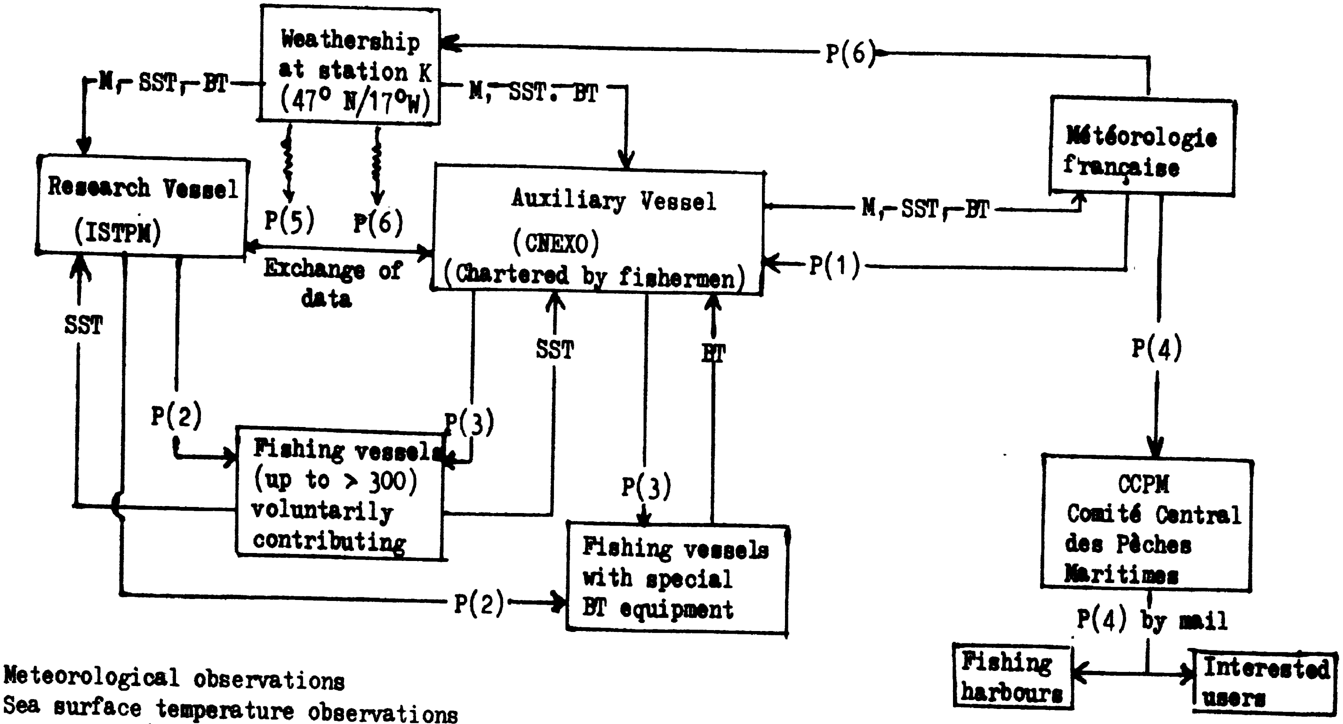
Figure 3:

Sea surface temperature (SST) chart for the North Atlantic Ocean prepared by the French Meteorological Service and distributed by radiofacsimile to suitably equipped fishing vessels (Document Météorologie française)

Figure 2: Scheme of collaboration within the French service for albacore fishery in the North Atlantic Ocean


Weathership at station K (47° N/17°W)
M, SST, BT
M, SST. BT
P(6)
Météorologie française
Research Vessel (ISTPM)
P(5)
P(6)
Exchange of data
Auxiliary Vessel (CNEXO) (Chartered by fishermen)
M, SST, BT
P(1)
SST
SST
P(2)
P(3)
BT
P(4)
Fishing vessels (up to > 300) voluntarily contributing
P(3)
Fishing vessels with special BT equipment
P(2)
CCPM Comité Central des Pêches Maritimes
P(4) by mail
Fishing harbours
Interested users

M = Meteorological observations
SST = Sea surface temperature observations
BT = Subsurface (bathythermograph) temperature observations
P = Environmental products:

- P-1: SST chart for the North Atlantic Ocean; Weatherchart and weather forecast; Chart describing the sea state (wave height, period and direction) plus forecast for 24 and 36 hours;
- P-2: Information Bulletin describing the oceanographic and fishery situation;
- P-3: Meteorological Bulletin and Fishery Bulletin (containing coordinates of 17°, 18° and 19°C isotherms) and frontal zones, and probable location 24 hours later;
- P-4: Special SST charts for the actual fishing grounds, prepared for operational decisions;
- P-5: Message on depth and thickness of thermocline in the actual fishing grounds also informing on the temperatures at the top and at the bottom of the thermocline;
- P-6: Meteorological Bulletin for the Eastern North Atlantic Ocean

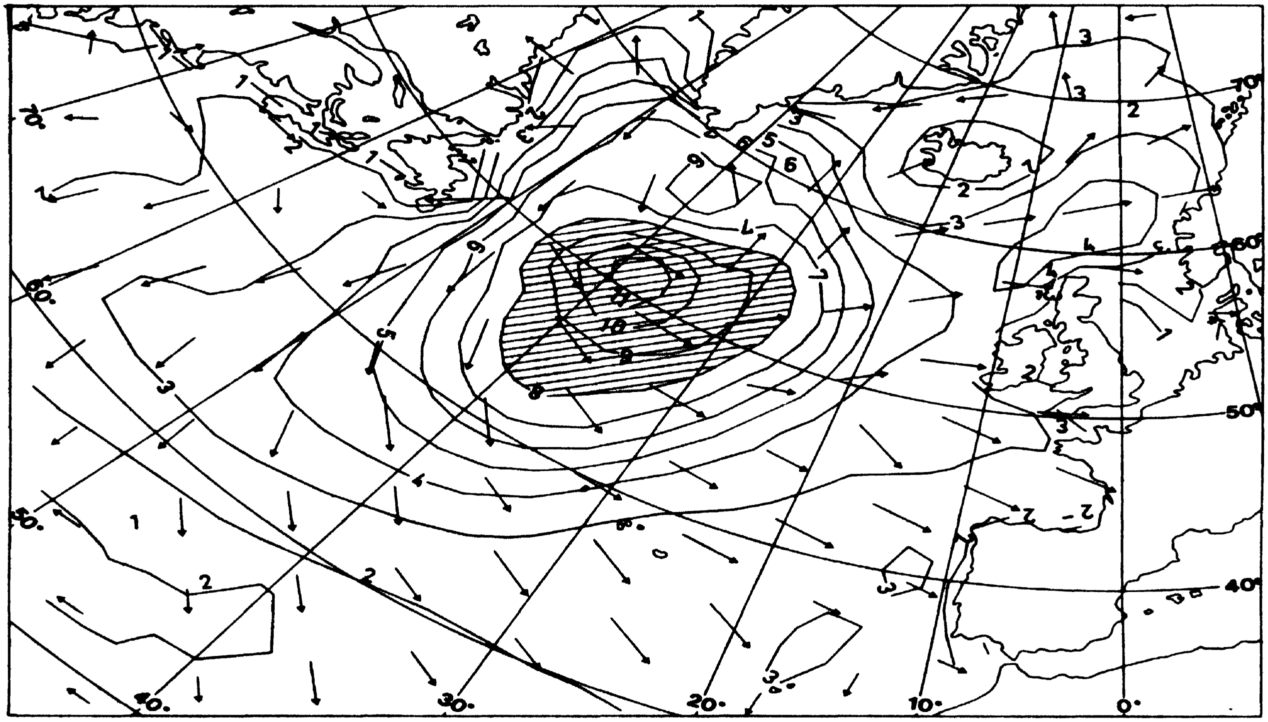


Figure 4: Chart showing the sea state in the North Atlantic Ocean on 15 June 1976 prepared by the French Meteorological Service for the facsimile distribution (Figures = wave height in metres; arrows indicating wave direction and, by the length of arrows, wave period). (Document Météorologie française)

4. SEA SURFACE TEMPERATURE MEASUREMENT BY AERIAL RADIOMETRY AND TUNA CONCENTRATIONS IN THE GULF OF GUINEA [1]

by

J.-M. Stretta

4.1 Introduction

For the past 20 years, ORSTOM oceanographers based at Dakar, Abidjan and Pointe Noire, have studied many sectors of the tropical Atlantic during various seasons. These campaigns, which have already been evaluated or are being processed, are aimed at defining the conditions under which radiometric investigations could be envisaged at different times to shed light on the relationships between environment and tuna.

Results of oceanographic cruises together with radiometric operations provide the data on hydrologic surface and subsurface structures which are needed to determine probable fish behaviour under conditions favourable for concentrations.

Such assumptions regarding the mechanisms of tuna concentrations are at present valid only in the Cape Lopez area or in similar zones, such as the area of Cape Three Points in August, the only sectors where integrated ship-plane operations have been carried out since 1972.

4.2 Background

Tuna concentrations are affected by water temperature and available feed (plankton, micronekton, sardines): Thus, yellowfin tuna is generally found in water of which the surface temperatures range from 23° to 29°C whereas skipjack can develop in considerably colder waters (up to 18°C).

It is difficult to solve directly the problem of locating tuna feed. Theoretically it can be done by using available data on surface temperature and subsurface thermal structures, such as thermocline depth. Such data on the environment in time and space are provided by satellites and aeroplanes equipped with infra-red radiometers which give repeated synoptic views of thermal surface conditions, the underlying conditions being deduced from the surface by means of hydrologic models available for each region.

On the basis of environmental data, it is possible to delimit areas rich in phytoplankton and zooplankton where potential tuna feed will be abundant. In some sectors of the Gulf of Guinea, cold water may rise and cool the surface water. When such cold water, which is generally rich, comes into contact with warm water, a front is formed (e.g. the front between São Tomé and Cape Lopez in June and July). This front promotes the development of plankton which serves as feed for small pelagic fish and micronekton which, in turn, serves as feed for Thunidae. Tuna will then be concentrated at the boundary of the front in warm waters where it finds favourable conditions of temperature and feed. This shows the fundamental importance of fronts in working out concepts for a fishing strategy.

4.3 Environmental product preparation based on aerial radiometry

For investigations of favourable front areas, the foremost parameter available was the surface temperature measured with an infrared radiometer on board a plane.

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[1] Aerial radiometric operations have received financial support from Centre National pour l'Exploitation des Océans (CNEXO)

Field operations involve a series of daily flights and data evaluation for forecasting. The plane flies at an altitude of 150 metres in the morning when the fishing fleet is fishing or looking for fish. Sampling straight downward from oceanographic vessels (Capricorne, Nizery) provides a daily chart of temperatures, with an accuracy of 0.2 centigrade. The crew comprises a pilot, a navigator-observer maintaining radio contact with the fishing fleet, and two scientists operating the measuring devices and drawing the charts during the flight. The results recorded in flight are constantly available for immediate transmission.

Data processing immediately after the flight is the most original and fundamental aspect of this kind of work. There is first of all the drawing of the charts which calls for a reconstruction of flight conditions, extrapolation of previous charts and interpretation in line with known oceanic phenomena because the flight is of limited duration and charting based on only one survey of data is possible only if the sector to be explored is small and the flight plan established previously proves effective for a description of the phenomena (Figure 1).

The chart drawn in this way is analyzed and fitted into the general patterns of thermal evolution of the sector concerned. In this way it is possible to show the trends and define certain areas favourable for tuna concentrations. A bulletin forecasting the fishing potential is then drafted and transmitted to the fishing fleet on the following day, together with a general analysis of the situation. These results and the forecasts make it possible to work out the flight plan for the next day, which has to be optimized in relation to the general thermal situation and the dispersion of the fishing vessels.

These operations have been carried out to a full extent only in the area of Cape Lopez and off Ivory Coast during a limited period. Time and space were particularly favourable for a thorough study of the processes.

4.4 Present development and prospects for application of remote measurements

At present, only the Cape Lopez operation has reached operational level. In June and July 1976, the forecasts on fishing areas were improved and fishing vessels informed of favourable zones 24 to 72 hours in advance. Moreover, daily information is provided by satellite at Libreville (surface temperature, weather conditions). This experiment will enable the service to define more modern concepts for fishermen, which are needed for medium-term strategy.

New remote-sensing techniques will help improve the forecasting model: with a team of researchers from the Science Faculty of Lille University we have tried to measure surface chlorophyll.

While the forecasting model at present applies only to the Cape Lopez area and sectors with similar hydrologic conditions, the method for approaching the phenomenon of tuna concentrations is valid for other regions as well: in the tropical Atlantic, there are zones of tuna concentrations which should be investigated in the traditional manner by oceanographic vessels before being explored by aerial surveys.

In view of future conditions for rational exploitation of stocks, together with increasingly keen competition among fishing fleets and future laws concerning the economic zones of coastal countries, it is essential to work out concepts for modern fishing strategies.

The strategy would rely on forecasting models to indicate available fish in traditional areas and in sectors newly explored by integrated ship-plane research.

In the years to come, use will have to be made of existing means, such as bathythermographs that can be released from planes for investigating subsurface structures, multispectrum cameras to analyze the colour of water, and laser rays to detect schools of tuna below the surface.

The technical means available in the next decade, especially in the field of weather and oceanographic satellites, should make it possible to work out long-term forecasting models providing the basis for fishing strategy on a world scale.

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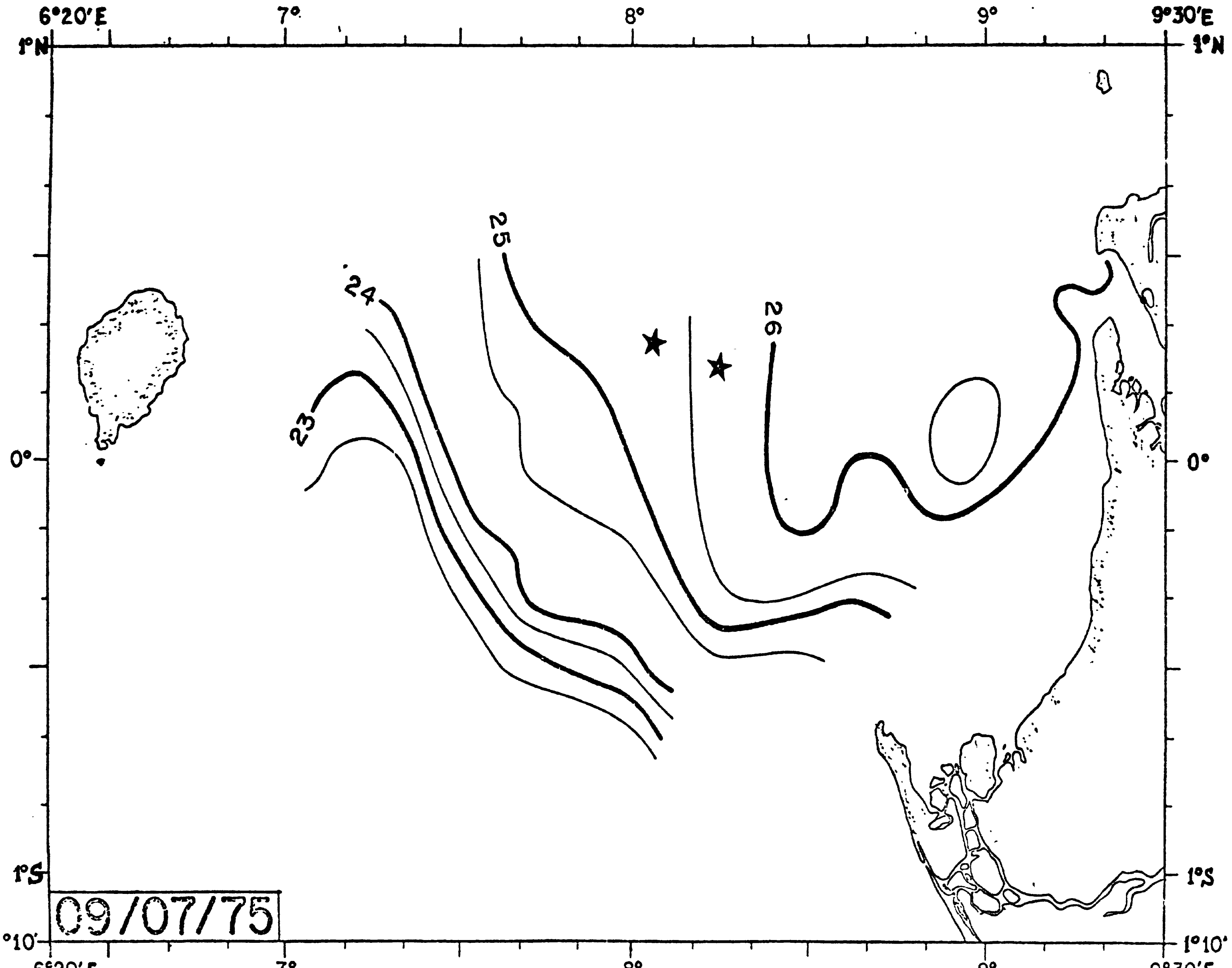

Figure 1: Sea surface temperature map for the Gulf of Guinea, 9 July 1975
(* = location of tuna fleet)

5. THE JAPAN FISHERIES INFORMATION SERVICE CENTER (JFIC)

by

G.H. Tomczak[1]

5.1 Introduction

Fish and its products play a very important role in the Japanese diet. Therefore effective utilization of fisheries resources in the sea areas adjacent to Japan is a matter of economic importance.

Thousands of fishing boats are engaged in mackerel, sardine, anchovy, saury, squid, tuna, swordfish and other fisheries in the western Pacific Ocean. Of the total catch of the Japanese fishing fleet in 1975 - 10,508,451 metric tons - about two thirds came from this area, and Japanese fishermen contributed more than 40 percent of the total catch by all countries fishing there.

In view of the high importance of Japanese fisheries extensive research in this field has been carried out in Japan, especially through the Regional Fisheries Research Laboratories and Prefectural Fisheries Experimental Stations which, jointly supported by fisheries associations and the fishing industry, also started in 1964 the first experiments to provide fishermen with "real-time" information on oceanographic and fisheries conditions in the various fishing grounds. These experiments were aimed at providing information on the sea-surface temperature distribution in the area and at monitoring surface currents and their displacement in order to facilitate scouting for commercially important fish.

Although there is still no clear understanding of both oceanographic, biological and physiological processes concerning the species for which predictions are made, experience has shown that valuable assistance can be given to fishing fleets by such forecasting services. Therefore in April 1972 the Japan Fisheries Information Service Center (JFIC) was established [2], whose work is described below.

5.2 Scientific background

The influence of water temperature on fish behaviour has been shown by many research workers. It is most pronounced during spawning, and for species in the areas adjacent to Japan this was found by various authors, e.g. Uda (1959) concerning sardines, Hayasi (1967) concerning anchovy, and Kawana (1934) and Uda (1952) concerning tuna.

However, there are temperature preferences also for adult fish which together with the availability of food influence the abundance, migration and schooling of fish. Thus it has been shown that fish tend to concentrate at certain surface isotherms, particularly in areas of strong horizontal temperature gradients. Therefore, best fishing grounds are frequently located in the boundary regions of different water masses or currents or in areas of divergence by upwelling processes.

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[1] See acknowledgements, page 37

[2] Japan Fishery Information Service Center, Kairaku Sotokanda Building, 5th Floor 53, Sotokanda 6-5-4, Chiyodaku, Tokyo (Japan) - Director: Dr. Eiichi Okada

In the areas south and east of Japan such frontal zones of strong horizontal temperature gradients are regularly formed by the boundaries of the Kuroshio and Oyashio and by eddies of warm or cold water developing along these currents; also in the Japan Sea such conditions are favoured by the Tsushima current which splits up into various branches.

In view of the twofold significance of water temperature for the behaviour of fish, i.e. the absolute value as regards the temperature preferences and the relative values in connexion with formation of frontal zones, yearly and seasonal changes against long-term average conditions must be considered by the prediction service just as the possible displacement of the currents in the area.

5.3 Analyses and information provided by the service

As can be seen from the foregoing section, environmental analyses should be focussed on the analyses of sea-surface temperature (SST) distribution in the area. Such SST-charts may be supplemented where necessary and/or possible by similar charts showing the distribution in greater depths (50m, 100m, 200m).

The service has therefore set up a system for temperature observations and their transmission to the center (see section 5.4), based on which SST analyses are prepared during the fishing period in seven different sea areas around Japan for use by the various fisheries (sardine, anchovy, mackerel, saury, squid, skipjack, tuna, albacore, swordfish, salmon and others).

Table 1 (page 70) summarises the services which are provided by the JFIC. The first two columns show the areas for which SST-charts are prepared and the fisheries involved.

As can be seen from columns 3-5 of that table the charts contain additional information on oceanographic and fisheries conditions in these areas as well as, in some cases, information about landings at various fish markets and size and composition of the landings.

Descriptions of oceanographic conditions refer to the general current pattern, especially to the present location of the Kuroshio and inputs of cold water to the area from the Oyashio, to the location of frontal zones and to cold and warm water eddies; they also compare the present temperature conditions with long-term means in the area and give information on the general trend of the further development of oceanographic conditions.

With the exception of some areas in which - because of competition - the fishing industries and fishermen themselves do not want to have the situation interpreted concerning best fishing grounds, the charts also contain such interpretation and provide data on maximum, minimum and average catches at these locations, composition of catches (species, body length), and information on fish markets.

Examples of the various analyses are given in Fig. 2-8. Translations of the explanations contained in these charts are attached as Annex I.

5.4 Operation of the JFIC

In order to enable fishermen to make use of the charts for tactical and operational decisions during their fishing operations a system has been developed (see Fig. 1) which ensures a minimum of delay between the time at which the oceanographic observations were made and the time of transmission of the analyses to the users at sea. The system is established in close collaboration with fisheries agencies and associations, with hydrographic, meteorological and naval offices and with the fishermen.

As can be seen from Fig. 1, input of oceanographic and fisheries data to the JFIC comes both from coastal oceanographic stations and fish markets, and from fishing boats, research vessels and aeroplanes operating at sea. Whilst research vessels and aeroplanes collaborate on an irregular basis transmitting data when they are passing through the areas of interest to JFIC, fishing boats participate in the system regularly. Sea-surface temperatures are observed on board these boats several times a day and transmitted by radiotelephone or telex to the next coastal radio station in the morning of the following day.

From the incoming oceanographic data mean values for areas of 30 square miles are calculated by a computer which plots the resulting values into a map. An oceanographer then draws the isotherms using his experience in checking the validity of the values, interpreting the observations and preparing the texts which are added to the analyses as oceanographic information. The charts are sent by facsimile on the evening of the same day to the Central Fisheries Radio Station which transmits them to the fishing boats. At the same time they are sent by mail, either directly or via the Fisheries Experimental Stations, to fisheries agencies and associations and to the fishing industry.

The information on fisheries data which reaches the JFIC from the fish markets and the fishing grounds is used for short descriptions of fisheries conditions at the fishing grounds. In addition, daily and monthly reports on landings at the fish markets are prepared and transmitted to the landing markets, fishing boats (via the Central Fisheries Radio Station) and consumers (via the NHK Broadcasting Organization). Fisheries Agencies receive the daily reports by telex and monthly reports by mail.

5.5 Period of the service - frequency of distribution of analyses

The service provides information on oceanographic and fisheries conditions all the year round. For several areas, however, distribution of sea-surface temperature analyses and description of the oceanographic and fisheries conditions is restricted to the fishing season in the area.

More information about this and the frequency of distribution by facsimile and other types of communication is given in Table 1.

5.6 Further activities of JFIC and collaboration with other organizations

The following information on further activities of the JFIC and its collaboration with other organizations may be of particular interest:

5.6.1 Contribution to long-term forecasting and abundance of various species

The Fisheries Research Laboratories and the Fisheries Experimental Stations carry out - on a monthly and, for some sections, a bimonthly basis - observations on standard sections in inshore and offshore areas.

The data, together with information from the JFIC, are used to prepare long-term forecasts (in 2- to 6-month intervals) on the abundance of pelagic fishes, such as anchovy, sardine, mackerel, jack mackerel, skipjack, saury and squid.

The forecasts are mailed to fishermen, fisheries associations, agencies and organizations.

5.6.2 Use of satellite data

Collaboration has been established with the Remote Sensing Technology Center of Japan to inquire how observations of sea-surface temperature made by satellites can be used for the services provided by JFIC.

5.7 References

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Table 1: Services provided by the JFIC for fishermen - part 1

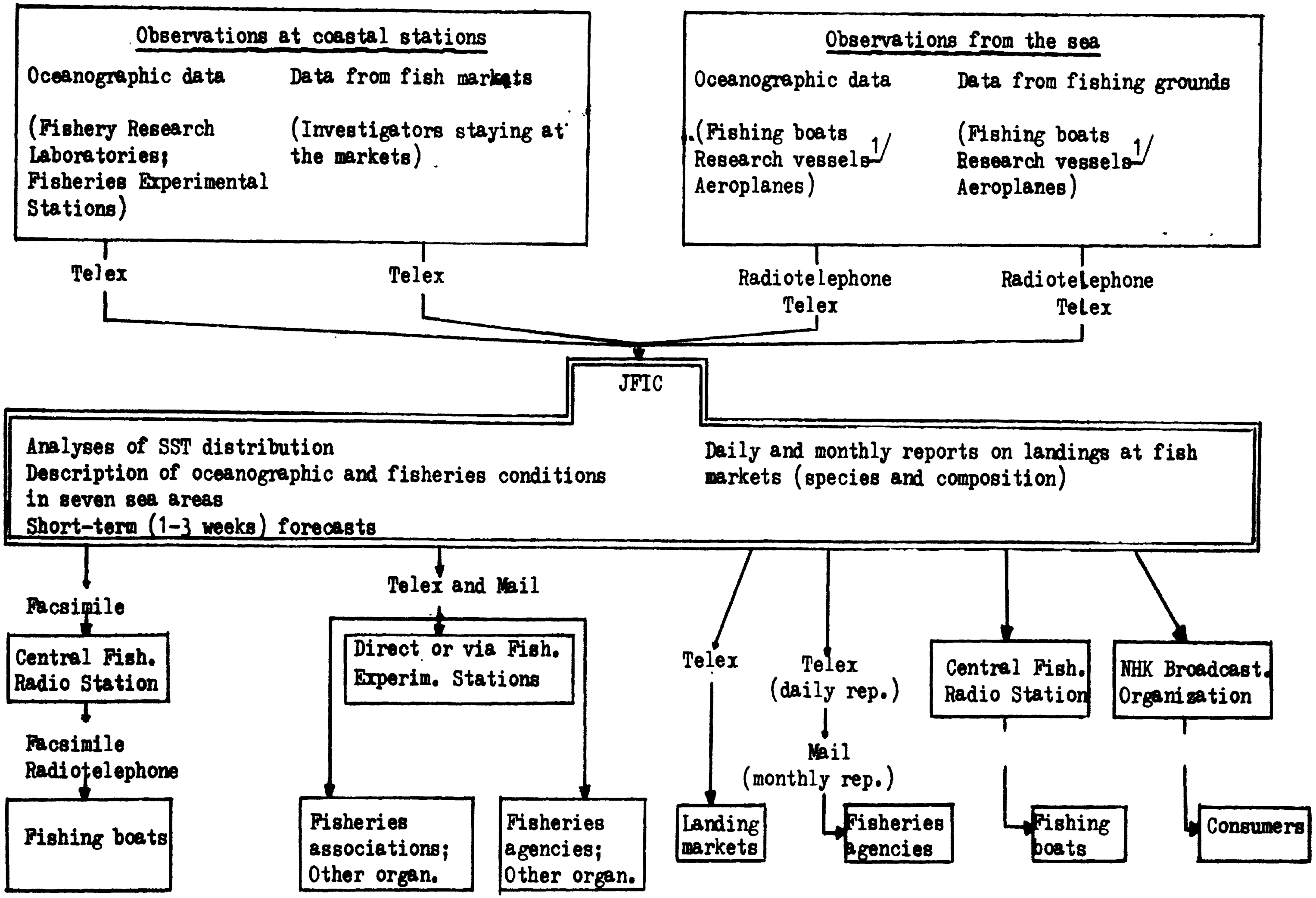
Area	Lat. N	Long. E	Fisheries involved	Information about Oceanographic conditions	 Fisheries conditions
North Pacific Ocean, South of Japan	22°-36°	124°-145°	Sardine, anchovy, saury, mackerel, skipjack, squid, and others	Present situation of Kuroshio Current; frontal zones; input of cold water from the north	Searching for fishing grounds is based on description of oceanographic conditions
North Pacific Ocean, South of Japan	35.5°-44.5°	140°-156°	Sardine, anchovy, saury, mackerel, skipjack, squid, and others	General description of sea surface temperature	Present location of fishing grounds and maximum and average fish catches made there
Western North Pacific Ocean	39°-49°	from Japan to 180°	Salmon, trout, skipjack	Present temperature conditions compared with mean distribution at that time of the year; frontal zones	No information on present fishing grounds
Japan Sea			Common squid, mackerel, jack-mackerel, sardine, yellowtail, tuna and others	General review of temperature distribution, present situation of polar front and various branches of the Tsushima Current	Present location and possible shifting of fishing grounds; max., min. and average catch in offshore and coastal fishing grounds
Nansei and Tokai coastal area	27°-35°	126°-140°	Juvenile yellowtail, sardine, anchovy, skipjack, tuna and others	Present situation of the Kuroshio Current with special attention to warm and cold eddies	No information on present fishing grounds
North-west Pacific Ocean	27°-46°	from Japan to 160°	Salmon, trout, skipjack	Comparison of temperature distribution with long-running average situation. Detailed description for several sub-areas as regards temperature distribution and currents	Present location of fishing grounds with near-term forecast of fishing conditions in these areas; Size and composition (body length) of catches
North Pacific Ocean	from Bering Sea to about 30°N		Salmon, trout, skipjack, albacore, swordfish	General distribution of temperature; frontal zones; current directions; eddies	Location of fishing grounds

Table 1: Services provided by the JFIC for fishermen - part 2

Fish markets	Period	Frequency of distribution	Transmission[1] to users by	Example: Map No.	Additional information
No information	April-June	3 times/week	facsimile, radio-telephone, mail	A	No
Data on landings at various fish markets	July-Dec.	3 times/week	facsimile, radio-telephone, mail	B	No
No information	April-July	twice/week	facsimile, radio-telephone, mail	C	No
Data on landings at various fish markets (weights, body length, etc.)	Jan.-Dec.	weekly	facsimile, radio-telephone, mail	D	Temperature distribution in 50m and 100m depth
No information	Jan.-Dec.	weekly	facsimile	E	No
Data on landings at various fish markets; comparison with former landings, number of fishing boats landing fish at these markets	Jan.-Dec.	every 5 days	facsimile, radio-telephone, mail	F	Occasionally other information, such as long-term forecasts on distribution and abundance of fish; temperature distribution in various depths; current pattenrs
No information	Jan.-Dec.	every 5 days	facsimile	G	General comments on weather conditions

[1] Broadcasts via Central Fisheries Radio Station

Figure 1: Flow of information within the system established by the JFIC


Observations at coastal stations
Oceanographic data
(Fishery Research Laboratories; Fisheries Experimental Stations)
Data from fish markets
(Investigators staying at the markets)
Observations from the sea
Oceanographic data
(Fishing boats Research vessels1/ Aeroplanes)
Data from fishing grounds
(Fishing boats Research vessels1/ Aeroplanes)
Telex
Telex
Radiotelephone Telex
Radiotelephone Telex
JFIC
Analyses of SST distribution
Description of oceanographic and fisheries conditions in seven sea areas
Short-term (1-3 weeks) forecasts
Daily and monthly reports on landings at fish markets (species and composition)
Facsimile
Central Fish. Radio Station
Facsimile Radiotelephone
Fishing boats
Telex and Mail
Direct or via Fish. Experim. Stations
Fisheries associations; Other organ.
Fisheries agencies; Other organ.
Telex
Landing markets
Telex (daily rep.)
Mail (monthly rep.)
Fisheries agencies
Central Fish. Radio Station
Fishing boats
NHK Broadcast. Organization
Consumers

1/ RV's from Fisheries Laboratories
Fisheries Experimental Stations
Hydrographic Department
Naval Office
Meteorological Agency

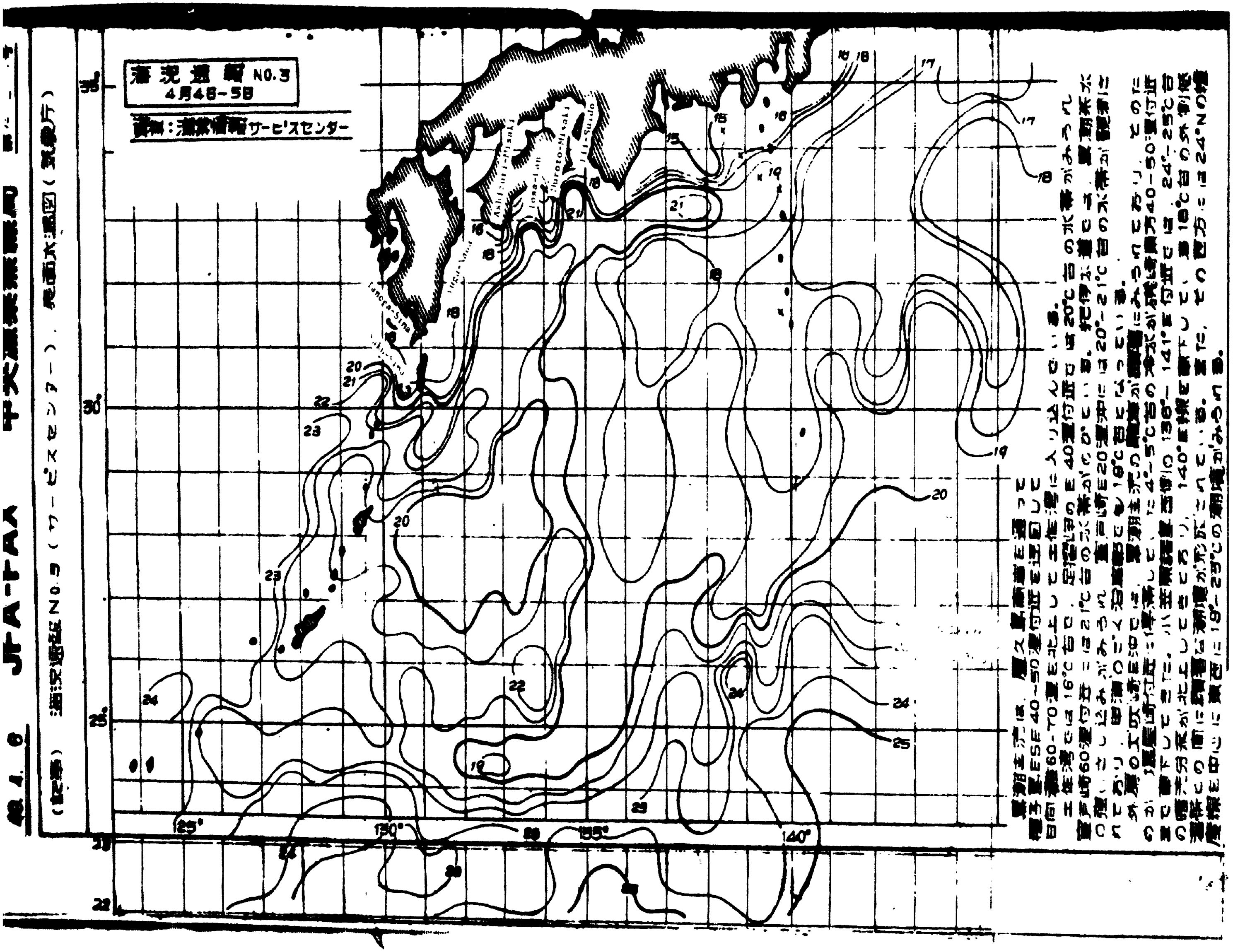
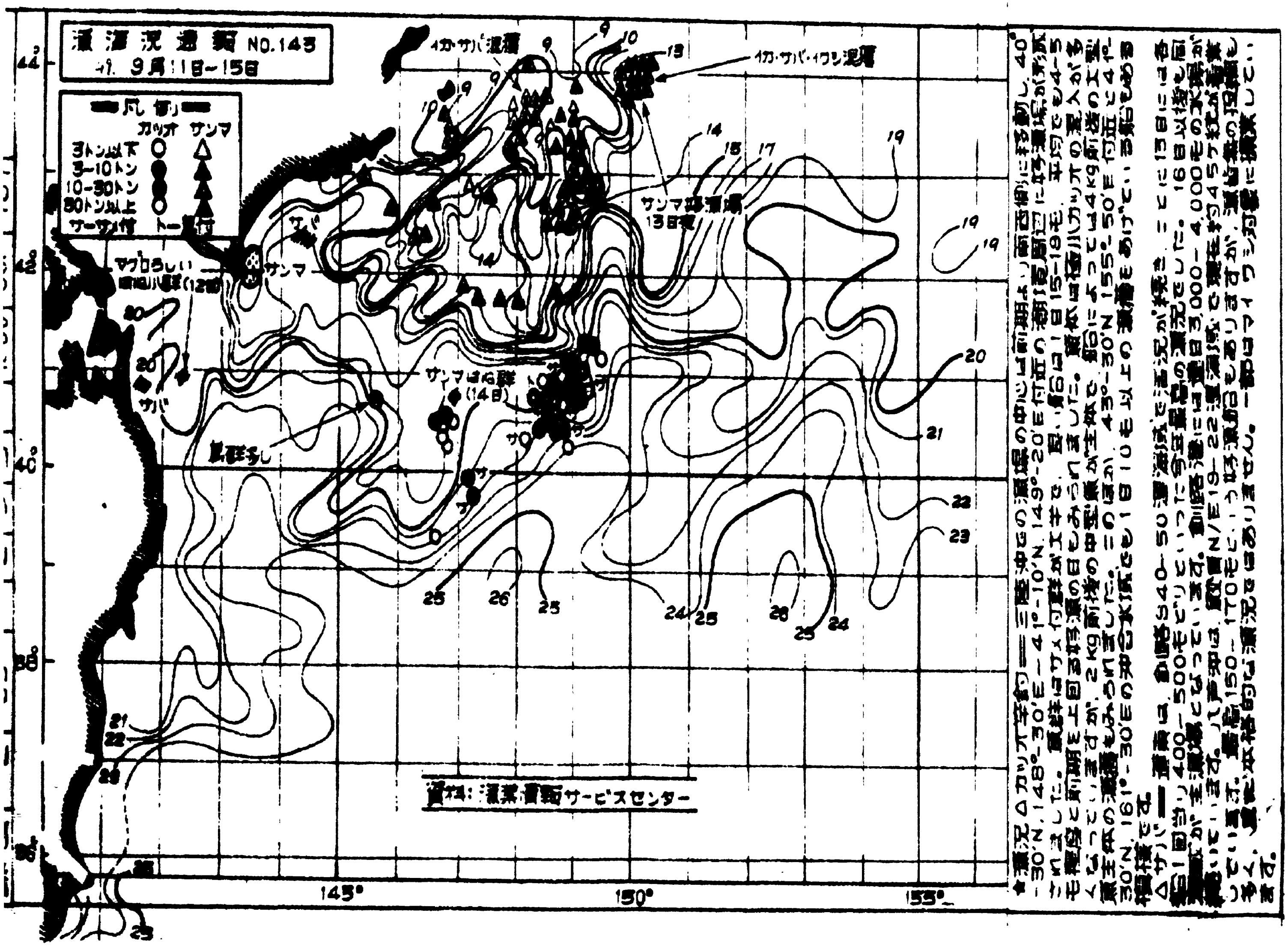


Figure 2: MAP A, North Pacific Ocean. south of Japan (Translation of Japanese text. see Annex I)



★漁況 △カツオ竿釣 ── 三陸沖での漁場の中心は前期より南西側に移動し、40°-30'N, 148°-30'E – 41°-10'N, 149°-20'E付近の潮境周辺に好漁場が形成されました。魚群はサメ付群が主体で、良い船は1日15-19t、平均でも4-5t程度と前期を上回る好漁の日もみられました。魚体は極小カツオの混入が多くなっていますが、2kg前後の中型魚が主体で、船によっては4kg前後の大型魚主体の漁獲もみられました。このほか、43°-30'N 155°-50'E付近と41°-30'N, 161°-30'Eの沖合水域でも1日10t以上の漁獲をあげている船もある模様です。

△サバ ── 道東は、釧路S40-50浬海域で漁況が続き、ことに13日には各船1回当り400-500tどりといった今年最高の漁況でした。16日以後も同海域が主漁場となっています。釧路港には連日3,000-4,000tの水揚が続いています。八戸沖は、鮫角N/E19-22浬海域で現在約45ヶ統が操業しています。最高150-170tという好漁船もありますが、漁皆無の投網も多く、まだ本格的な漁況ではありません。一部はマイワシ対象に操業しています。

Figure 3: MAP B, North Pacific Ocean, south of Japan
(Translation of Japanese text, see Annex I)

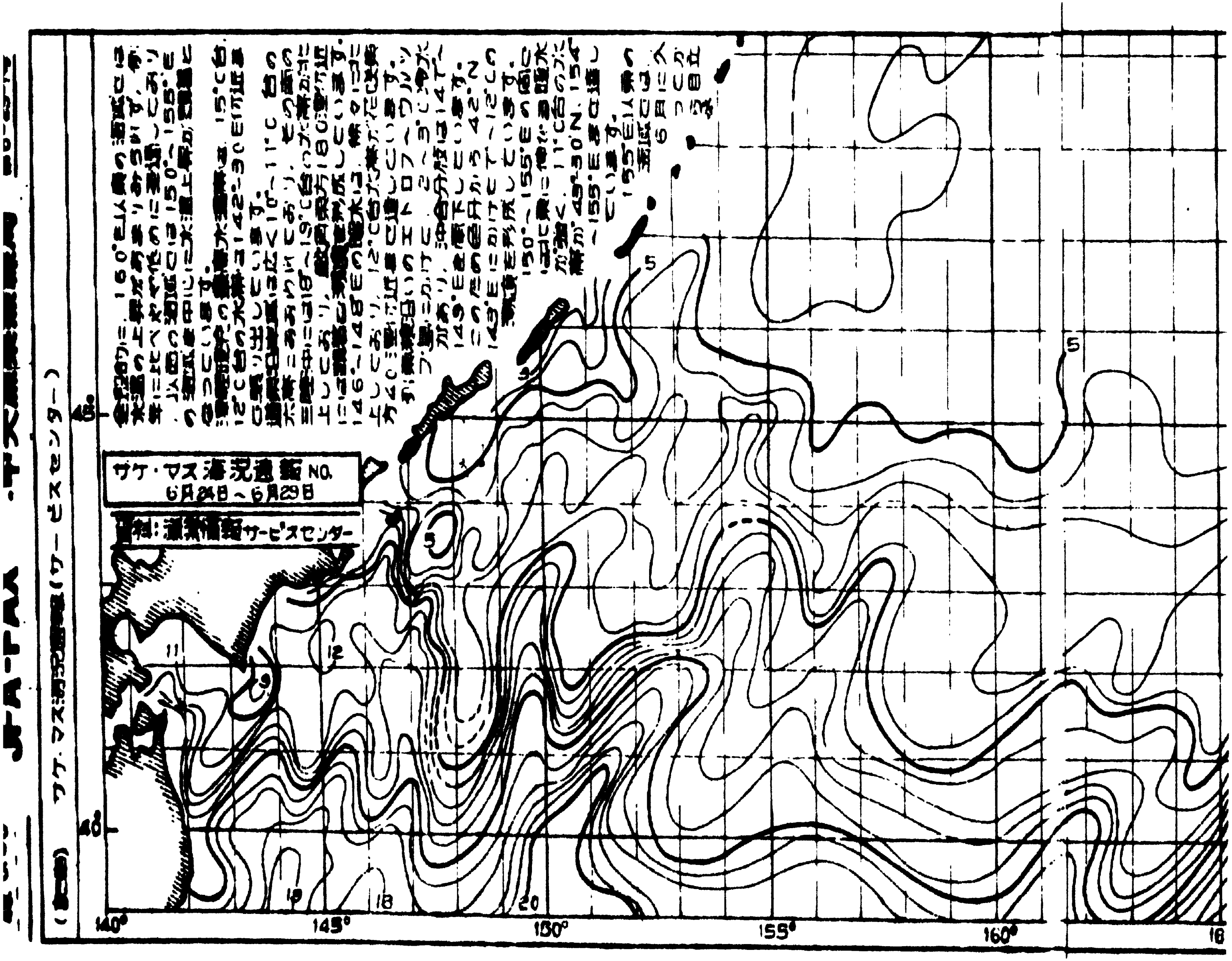
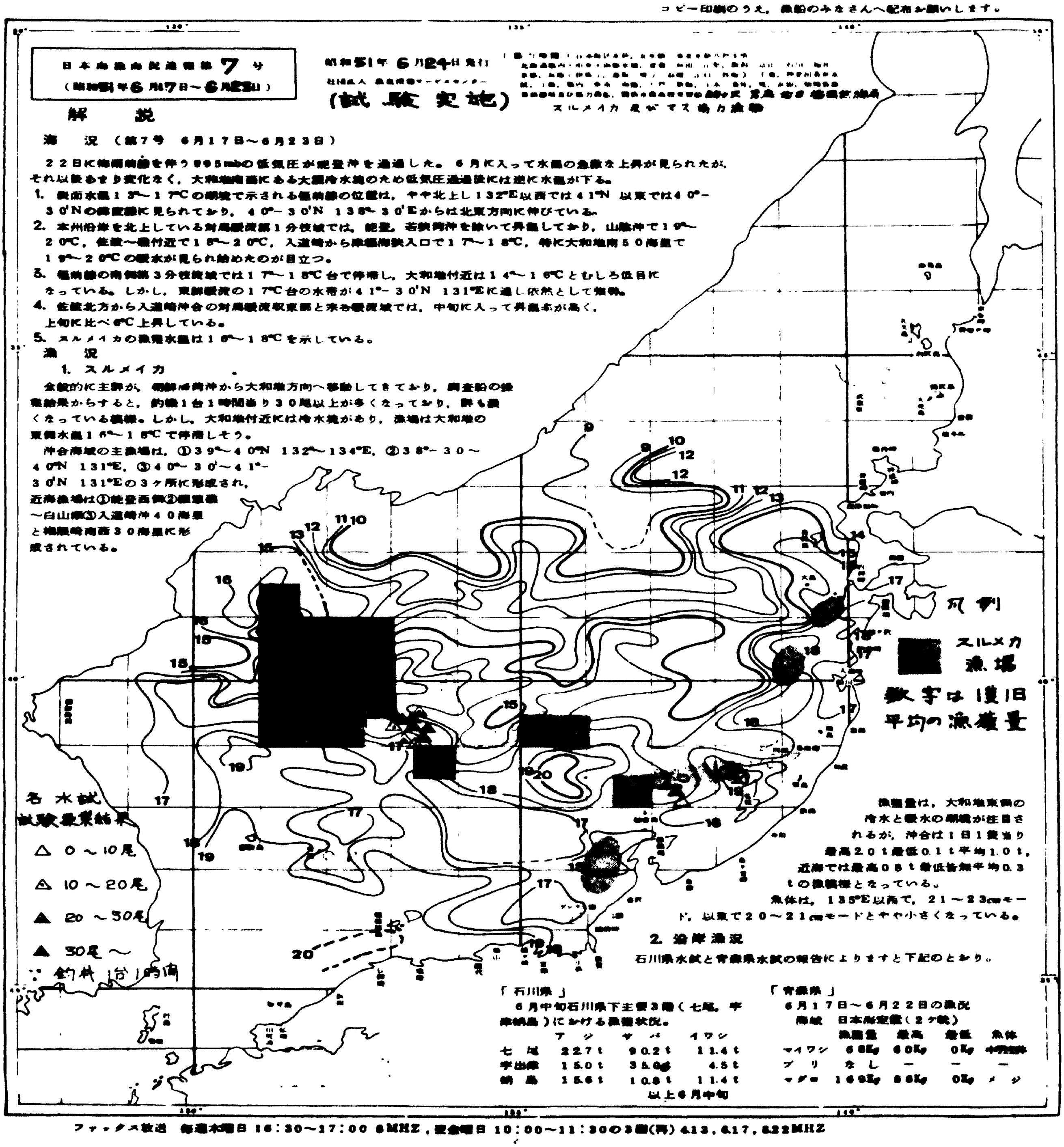


Figure 4: MAP C, Western North Pacific Ocean (Excerpt only: the original map covers the area from 140^0 to 180^0E; for translation of Japanese text see Annex I)



コピー印刷のうえ、漁船のみなさんへ配布お願いします。

日本海漁海況速報第7号
（昭和51年6月17日～6月23日）

昭和51年6月24日発行
社団法人 漁業情報サービスセンター
（試験実施）

[illegible]
スルメイカ及びマス協力漁船

解説

海況（第7号 6月17日～6月23日）

22日に梅雨前線を伴う995mbの低気圧が能登沖を通過した。6月に入って水温の急激な上昇が見られたが、それ以後あまり変化なく、大和堆南西にある大量冷水塊のため低気圧通過後には逆に水温が下る。

1. 表面水温13°～17°Cの潮境で示される極前線の位置は、やや北上し132°E以西では41°N 以東では40°-30'Nの緯度線に見られており、40°-30'N 138°-30'Eからは北東方向に伸びている。
2. 本州沿岸を北上している対馬暖流第1分枝域では、能登、若狭湾沖を除いて昇温しており、山陰沖で19°～20°C、佐渡～[illegible]付近で18°～20°C、入道崎から津軽海峡入口で17°～18°C、特に大和堆南50海里で19°～20°Cの暖水が見られ始めたのが目立つ。
3. 極前線の南側第3分枝流域では17°～18°C台で停滞し、大和堆付近は14°～16°Cとむしろ低目になっている。しかし、東鮮暖流の17°C台の水帯が41°-30'N 131°Eに達し依然として強勢。
4. 佐渡北方から入道崎沖合の対馬暖流収束部と宗谷暖流域では、中旬に入って昇温率が高く、上旬に比べ6°C上昇している。
5. スルメイカの漁獲水温は16°～18°Cを示している。

漁況

1. スルメイカ

全般的に主群が、朝鮮東湾沖から大和堆方向へ移動してきており、調査船の操業結果からすると、釣機1台1時間当り30尾以上が多くなっており、群も濃くなっている模様。しかし、大和堆付近には冷水塊があり、漁場は大和堆の東側水温16°～18°Cで停滞しそう。

沖合海域の主漁場は、①39°～40°N 132°～134°E、②38°-30'～40°N 131°E、③40°-30'～41°-30'N 131°Eの3ヶ所に形成され、近海漁場は①能登西側②[illegible]～白山瀬③入道崎沖40海里と[illegible]崎南西30海里に形成されている。

漁獲量は、大和堆東側の冷水と暖水の潮境が注目されるが、沖合は1日1隻当り最高2.0t 最低0.1t 平均1.0t、近海では最高0.8t 最低皆無平均0.3tの漁模様となっている。

魚体は、135°E以西で、21～23cmモード、以東で20～21cmモードとやや小さくなっている。

2. 沿岸漁況

石川県水試と青森県水試の報告によりますと下記のとおり。

「石川県」

6月中旬石川県下主要3港（七尾、宇出津、輪島）における漁獲状況。

	アジ	サバ	イワシ
七尾	22.7t	90.2t	11.4t
宇出津	15.0t	35.0[illegible]	4.5t
輪島	15.6t	10.8t	11.4t

以上6月中旬

「青森県」

6月17日～6月22日の漁況
海域 日本海定置（2ヶ統）

	漁獲量	最高	最低	魚体
マイワシ	68Kg	60Kg	0Kg	[illegible]
ブリ	なし	—	—	—
マグロ	169Kg	86Kg	0Kg	メジ

ファックス放送 毎週木曜日 16:30～17:00 8MHZ、[illegible]金曜日 10:00～11:30の3波(再) 4.13, 6.17, 8.22MHZ

Figure 5a: MAP D. Japan Sea (Translation of Japanese text. see Annex I).

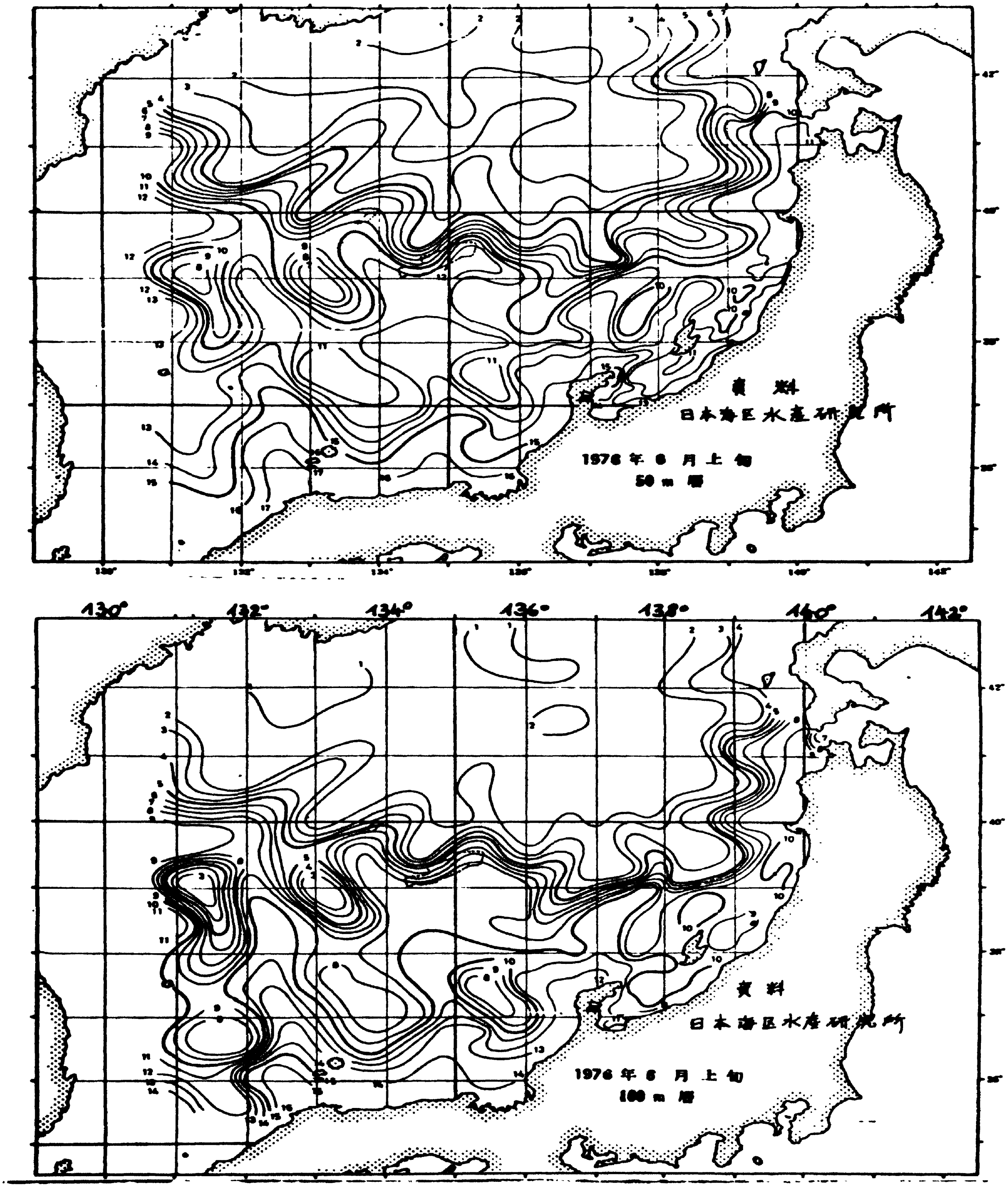


Figure 5b: MAP D, Japan Sea (reverse). Temperature distribution at 50m depth (above) and 100m depth (below)

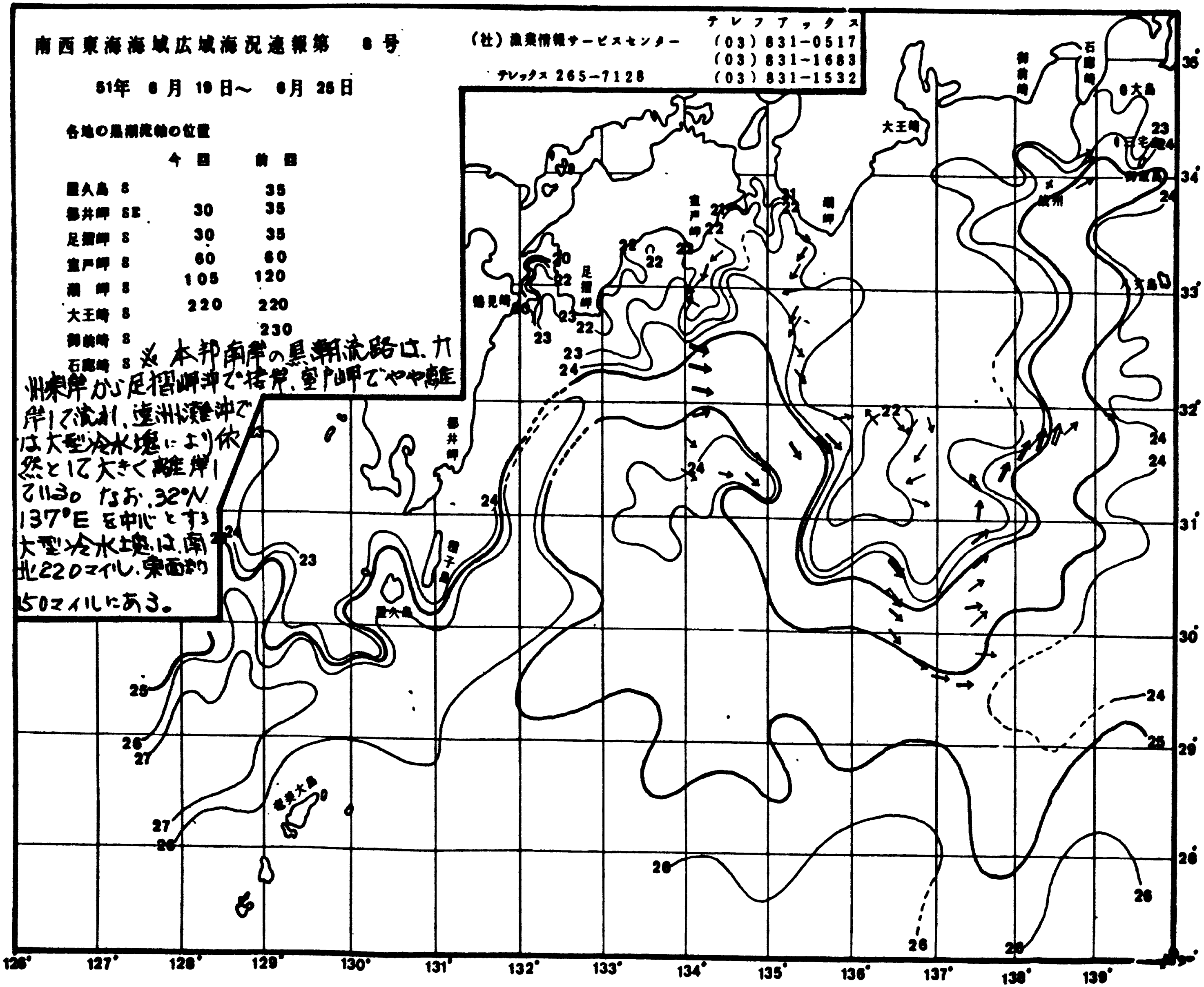
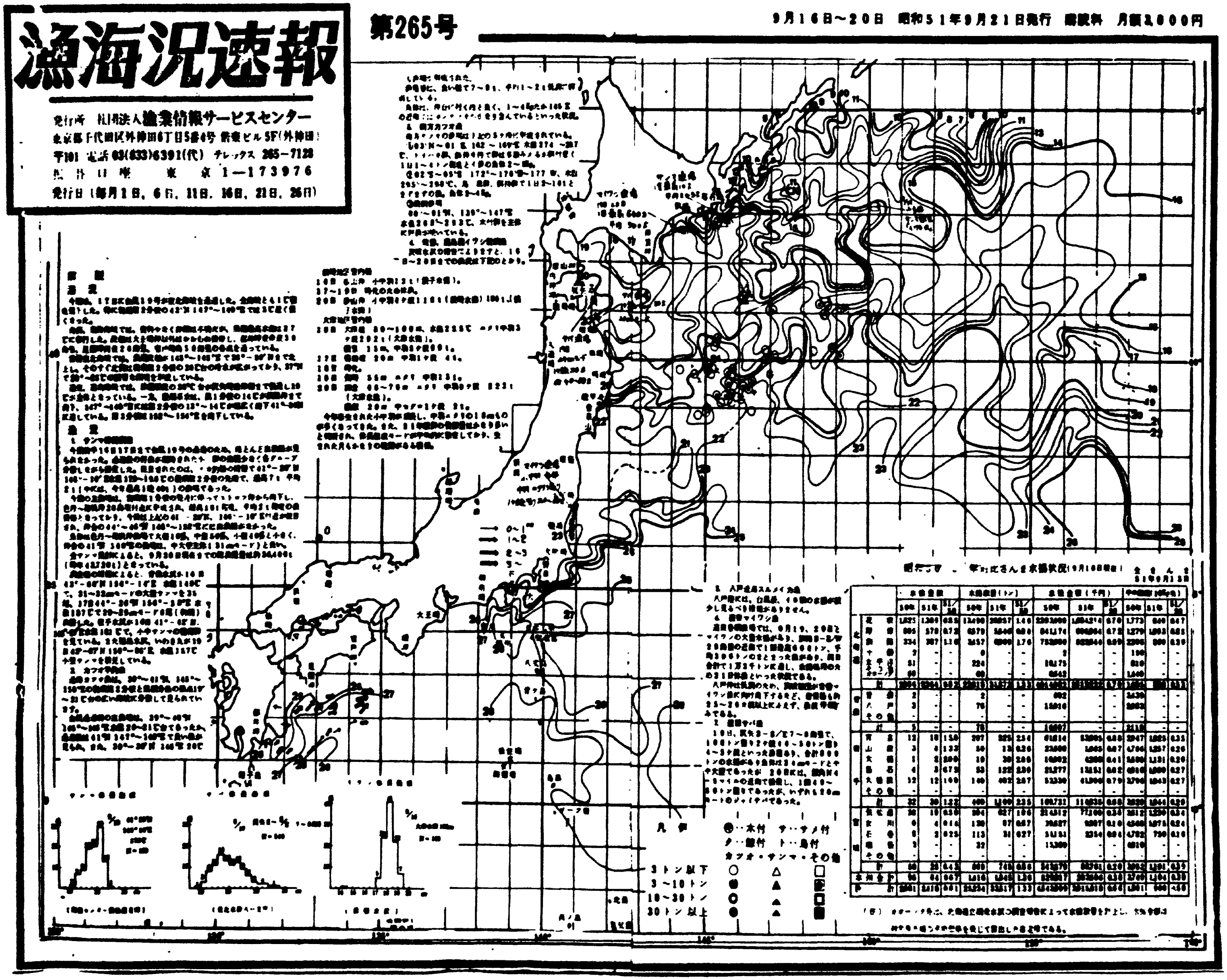


Figure 6: MAP E, Nansei and coastal area (Translation of Japanese text, see Annex I)



漁海況速報

第265号

9月16日～20日 昭和51年9月21日発行 購読料 月額2,000円

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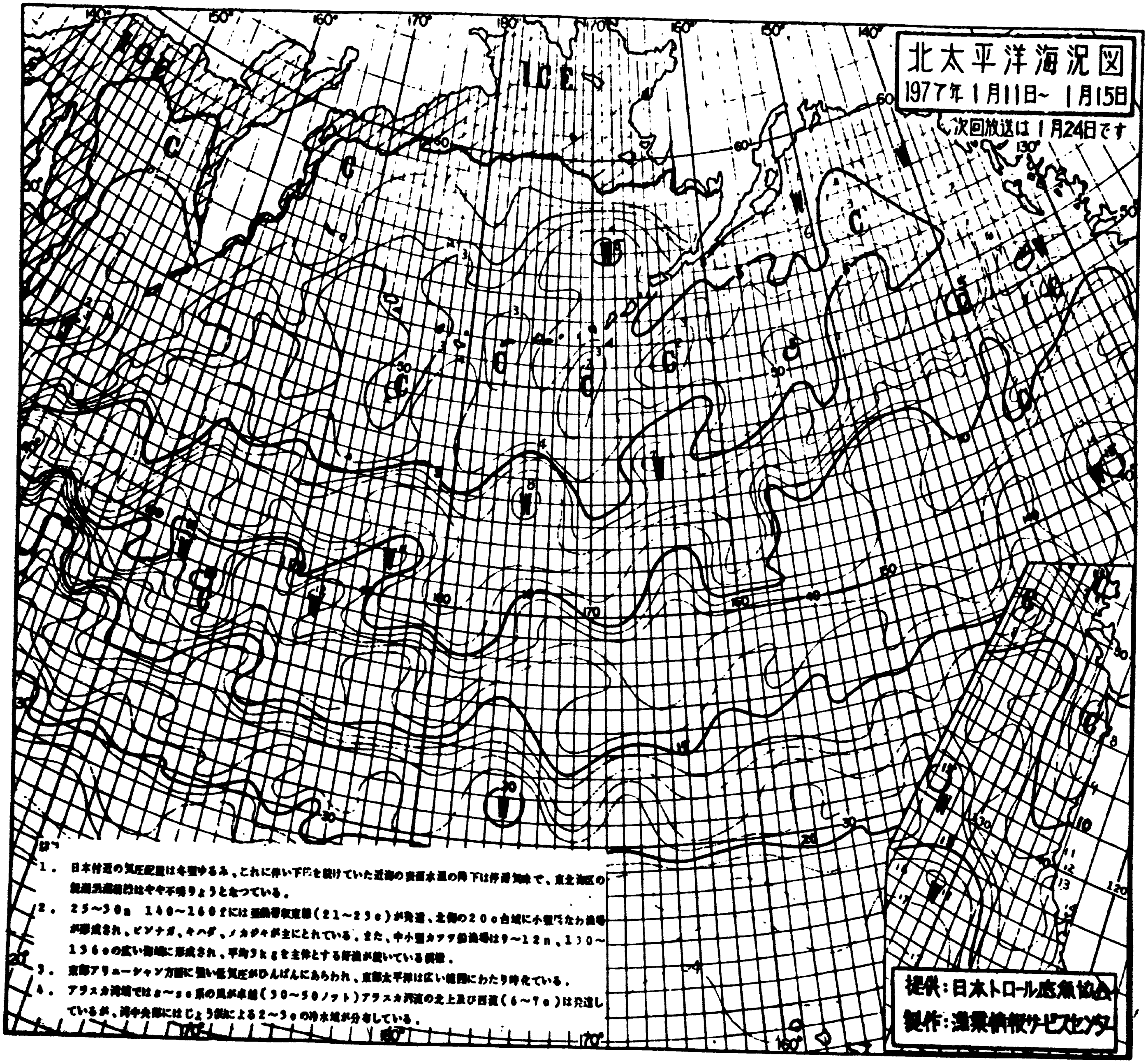
Figure 7: MAP F, North-west Pacific Ocean (Translation of Japanese text, see Annex I)



1. 日本付近の気圧配置は冬型ゆるみ、これに伴い下降を続けていた近海の表面水温の降下は停滞気味で、東北海区の[illegible]はやや不明りょうとなっている。
2. 25～30n 140～160eには亜熱帯収束線（21～23c）が発達、北側の20c台域に小型はえなわ漁場が形成され、ビンナガ、キハダ、メカジキが主にとれている。また、中小型カツオ釣漁場は9～12n、130～136eの広い海域に形成され、平均3kgを主体とする好漁が続いている模様。
3. 東部アリューシャン方面に強い低気圧がひんぱんにあらわれ、東部太平洋は広い範囲にわたり時化ている。
4. アラスカ湾域ではS～SE系の風が卓越（30～50ノット）アラスカ海流の北上及び西流（6～7c）は発達しているが、湾中央部にはじょう乱による2～3cの冷水域が分布している。

Figure 8: MAP G, North Pacific Ocean (Translation of Japanese text, see Annex I)

ANNEX I

TRANSLATIONS FROM MAPS A-G (Fig. 2-8)

Map A:

JFA-FAX (Japan Central Fisheries Radio Station)
April 6, 1974
Sea surface temperature, 4 to 5 April

The Kuroshio runs south of Yaku-Sima Island, 40 to 50 nm east-south-east of Tanega-Sima Island, 60 to 70 nm east of Hyuga-Nada and passes Tosa-Wan Bay. The sea surface temperature is 16°C at Tosa-Wan Bay, 20°C at 40 nm east of Ashizuri-Misaki and 21°C at 60 nm south-east of Muroto-Misaki. The Kuroshio water flows into Kii-Suido Channel, and there the coastal water temperature reaches 19°C. Because the Kuroshio seems to run far distant from Inubo-Saki, cold water with 4° to 5°C from the area of Shioya-Saki flows southward.

A branch of warm water with temperature of 24° to 25°C flows northward at 138° to 141°E west of Ogasawara Islands and forms a sharp frontal zone at 27° to 25°N. Another frontal zone exists at 125° to 135°E with temperature range of 19° to 23°C.

Map B:

Fisheries and oceanographic conditions
September 11-15, 1974
Fisheries conditions:

Skipjack

The main fishing ground east of Sanriku shifted to south-west compared to the last period, and is now situated near the frontal zone at 40°30'N, 148°30'E to 41°10'N, 149°20'E. Catches are better than during the last period (up to 15-19 tons/day; 4-5 tons on an average in shoals with sharks). The weight of skipjack is 2-4 kg; in addition, light skipjacks are caught. It seems that more than 10 tons/day are caught near 43°30'N, 155°50'E and 41°30'N, 161°30'E.

Mackerel

Good catches are continuing at 40 to 50 nm south of Kushiro. 400 to 500 tons were caught by one fishing boat on 13 September which is the maximum catch this year. 3000 to 4000 tons/day are landed at Kushiro fish harbour. 45 groups of fishing boats are fishing at 19 to 22 nm north east of Samekado. There the fish catch is small and mixed with sardine.

Map C:

Oceanographic conditions for salmon and trout fisheries
June 24-29, 1974

The sea surface temperature is a little too low compared with normal years and east of 160°E, will probably not rise, whilst west of 160°E it rises remarkably, particularly in the area between 150° and 155°E. The maximum temperature of the Tsugaru Warm Current is 15°C; the area with temperature of 12°C reaches to 142°30'E.

The coastal area east of Hokkaido is covered widely with water of 10°-11°C. Water with 18°-19°C covers the area east of Sanriku; a remarkable frontal zone is formed between these two water masses.

The warm water at 146°-148°E moves slowly northward; water with 12°C reaches to 40 nm east of Hanasaki. At 46°N, 151°E water with 2°-3°C can be found. A second branch of the Oyashio flows southward between 147° and 149°E. A sharp frontal zone is formed in the area off the Sanriku coast extending to 155°E. North of 45°N temperatures are steady (4°-6°C).

Map D:

Fisheries and oceanographic conditions in the Japan Sea
June 17-23, 1976
(Only excerpts from the Japanese texts are given below)
(i) Oceanographic conditions:

On 22 June a depression of 995 mb moved along the seasonal rainfront. The sea surface temperature suddenly rose at the beginning of June but dropped after the passage of depression due to a developing cold water mass in the south-western part of Yamato Tai.

Special comments:

The polar front region indicated by sea-surface temperatures of 13°-17°C moved a little to the north and is now found at 41°N in the area west of 132°E and 40°30'N in the area east of 132°E..... The temperature remains unchanged 17°-18°C in the region of the third branch of the warm Tsushima Current south of the polar front..... The temperature of the fishing grounds of common squid equals 16°-18°C.

(ii) Fisheries conditions:

The main school of common squid started to move from Tyosen Kaiwan to Yamato Tai. From experimental fishing by research vessels it can be estimated that the school becomes dense. Due to the cold water mass near Yamato Tai the fishing grounds will probably only shift to the west of Yamato Tai where temperatures are 16°-18°C. The offshore fishing grounds for common squid will thus form in 39°-40°N and 132°-134°E, 38°30'-40°N and 131°E, and 40°30'N and 131°E, respectively. The coastal fishing grounds are formed west of Noto Peninsula, north of Sado Island, 40 nm west of Cape Nyudo-Saki and 30 nm west of Tsugaru Peninsula.

The catches are 2.0t (maximum), 0.1t (minimum) and 1.0t (average value) per day and per fishing boat in the offshore fishing grounds, and 0.8t (max.), 0.0 (min.), 0.3t (average) in the coastal fishing grounds. The body length has the mode at 21-23 cm in the area west of 135°E, and at 20-21 cm in the area east of 135°E.

Coastal fishing: Jack-mackerel, mackerel and sardine landed in markets of Ishikawa Prefecture were as given in the table:

Market	Jack-mackerel	Mackerel	Sardine
Nanao	22.7t	90.2t	11.4t
Udetsu	15.0	35.0	4.5
Takoshima	15.6	10.8	11.4

Map E:

Oceanographic conditions in the Nansei and Tokai area
June 19-25, 1976

The Kuroshio runs adjacent to the coast from east of Kyushu to south of Cape Ashizuri-Misaki, deviates slightly from the coast at Cape Muroto Misaki and then turns to the south surrounding the cold eddy located at 32°N and 137°E in Enshu Nada.

The cold eddy covers an area of 220 nm in North-South direction and 150 nm in East-West direction.

Table showing the distance of the Kuroshio from various places in the given direction

Place	Direction	Present distance	Distance at last period
Yakushima Island	S	-	35 nm
Cape Toi-Misaki	SE	30 nm	35
Cape Ashizuri-Misaki	S	30	35
Cape Muroto-Misaki	S	60	60
Cape Shiono-Misaki	S	105	120
Cape Daio-Saki	S	220	220
Cape Omae-Saki	S	-	230

Map F:

Fisheries and oceanographic conditions
August 1-5, 1976

As in map D a detailed description of the oceanographic conditions is given together with special comments for different areas, i.e. the Nansei-Tokai area, the Enshu-Nada area, the Joban area and the area east of Hokkaido, and for the Oyashio Current.

The fisheries conditions described in the text refer to skipjack, saury and other fisheries.

The histograms show the distribution of body length of skipjack at various fishing grounds, also giving the number of samples taken and the sea surface temperature at these places.

The table contains statistical values for landings of saury in 1975 and 1976 in 20 fish markets. Figures give the number of fishing boats involved, the total landings (tons), the gross receipts (in units of 1000 yens), and the average prices per 10 kg.

The symbols contained in map F refer to the amount of catch per day and fishing boat:

o = < 3 tons
◉ = 3-10 tons
◎ = 10-30 tons

Map G:

Oceanographic conditions in the North Pacific Ocean
January 11-15, 1977

1. The atmospheric pressure pattern no longer corresponds to the real winter type distribution. Accordingly the sea surface temperature near Japan ceases to fall further. Kuroshio and Oyashio fronts become slightly indistinct in the Tohoku area, east of Japan.

2. The subtropical convergence indicated by the 21°-23°C is located in the area of 25°-30°N, 140°-160°E. Albacore, yellowfin tuna and swordfish are mainly caught in the northern edge of this region. The fishing grounds for skipjack are widely distributed in the area 9°-12°N, 130°-136°E. The catch of skipjack continues to be good (about 3 kg, on an average).

3. Following frequent forming of remarkable low pressure fields east of the Aleutian Islands the whole area of the eastern Pacific shows stormy weather.

4. According to the prevailing southerly and south-easterly winds with 30-50kn, currents in the Gulf of Alaska are directed to the north and west. A turbulent area with water temperatures of 2-3°C in the centre of the Gulf of Alaska is surrounded by these currents which show a water temperature of 6-7°C.

6. FISHERY SURVEILLANCE AND ADVISORY SYSTEMS IN SOUTHERN AFRICA

by

D.L. Cram [1]

6.1 Introduction

Searching accounts for a considerable proportion of the costs involved in the pelagic fishing operation (Norton, 1970) and the value of aircraft has long been recognized as a means of reducing search-time. Aerial assistance has rarely been instrumental in establishing new fisheries (e.g., Wilson, 1965); assistance is normally required only when established fisheries suffer a reduction in catches and it is felt that more search effort is needed (e.g., Anon, 1919; Harrison, 1931; Squire, 1961; Anon, 1968).

This is true for the two major pelagic purse-seine fisheries administered by the Sea Fisheries Branch where, despite aerial efforts, search methods are still relatively unsophisticated.

The South African (Cape) pelagic fishery which is based upon six harbours spread along 700 km of coastline, is predominantly a fishmeal industry and has had a commercial aerial scouting system operating (with breaks) since 1967. The South West African (SWA) pelagic fishery is based almost entirely upon one port, with only minor activity (< 10%) at another; it is predominantly a canning industry and has had a scientific aerial research programme since 1970 with a small-scale commercial operation intermittently since 1975.

Differences in structure and objectives of the two fisheries cause differences in the search activities of their fishing fleets. The Cape fishermen, who exploit a relatively small multispecies fish population over a wide area, tend to be guided by their aerial scouting service and search a larger geographic area when fish are scarce. The SWA fishermen exploit a larger multispecies fish population but are limited in search area by the canneries' requirements of fresh fish (Figure 1).

Shoaling pelagic fish in these coastal upwelling zones have proved difficult to locate by ecological inference, the preferred method being direct visual location, mostly by night.

An effective surveillance and advisory system should be able to:

- monitor the distribution of the various species within the management area on a regular basis;
- accurately guide fishing vessels to the nearest commercially valuable concentration of fish;
- aid the skipper in the choice of a shoal upon which to set and to render advisory assistance as the shoal is approached and the net set.

Direct observation of shoals by aircraft spotters using the eye or low light level television (LLLTV) will allow this. Aircraft observations should be directly transmitted to the fishing vessel engaged in the fishing operation, thus placing the information where and when it is required. The acquisition of primary distributional data in documentary form inevitably means a delay of up to 24 hours before the fishing operation can recommence. By this time the distributional data is out of date: especially if navigational facilities on the fishing vessels are inadequate, sonar conditions poor, and the shoals mobile. Direct observation removes the need for costly information processing, dissemination and transmission facilities.

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[1] This chapter was prepared for FAO by kind permission of the Director of Sea Fisheries, Dr. B. van D. de Jager

From the scientific point of view, the collection of all aerial data should be influenced by scientific principles; the data should be integrated with catch statistics data, population biology, oceanographic data, etc. to produce an annual inventory of the stocks from which realistic forecasts can be made of the fisheries performance for the next fishing season.

6.2 Factors affecting aerial observations of fish shoals

Pilchard (*Sardinops ocellata*), anchovy (*Engraulis capensis*), mackerel (*Scomber japonicus*), red-eye herring (*Etrumeus teres*), maasbanker (*Trachurus trachurus*) and lantern-fish (*Lampanyctodes hectori*) can be located around Southern Africa by direct observation. Some species can be detected both at night or in daylight, although in general results are best at night.

6.2.1 Night-time observations

Fish shoals are visible at night by stimulated plankton bioluminescence down to a depth of about 12m. This light is visible with the eye to at least 300m altitude under normal conditions and up to 2,500m under exceptional conditions. Such direct observations are quite adequate for the commercial fishspotter not requiring any quantitative information upon shoal dimensions. The eye adapted to the dark is sensitive to an irradiance of 1.0 x 10^{-8} µW/cm^2 of retina at 510nm when an object subtending 47° to the eye is illuminated (Clarke and Denton, 1962); 510nm is near the peak of bioluminescence spectral energy emission. Most fish shoals around Southern Africa are capable of exciting bioluminescence in excess of these specifications. In addition, the eye has a wide dynamic range, very wide field of view and excellent resolution. Unfortunately, there is little that can be done with observations by the unaided eye. Electro-optics devices can be built with greater sensitivity than the eye but poorer in all other characteristics. An image intensifier equipped with a large scanning prism has been successfully used in the U.S. menhaden fishery in the Gulf of Mexico (Brennan and Dyer, 1976). LLLTV systems can be custom-built for use in a fisheries mode which allows the recording of images for later use (Cram 1972, 1974; Malan *et al*., 1977; Zapata, 1977). Diurnal vertical migration is an advantage in the night-time detection of fish, whose behaviour is the only, and fairly unreliable, source of identification.

6.2.2 Day-time observations

Fish shoals are visible to the eye by reflected sunlight to depths reported as being very variable. Mackerel is the only fish species which has been consistently sought during day-time off the Cape. Shoals are visible from high altitude and day spotters have the advantage of descending to low altitude for identification purposes. Species are frequently identifiable by colour, texture or behaviour, or by observing single fish. Other factors which can guide the spotter are water colour, surface features such as "slicks", visible currents or frontal systems and predator activity (Squire 1961, 1972). Shoals may be photographed or examined with a variety of sensors (Benigno, 1971). Diurnal vertical migration is a disadvantage to the day spotter.

6.3 Description of existing systems

There are three different advisory systems: (i) a commercial aerial scouting system along the South African Atlantic coast which locates luminescent areas and directs sonar equipped vessels; (ii) a scientific system which provides feedback to the industry by combining an LLLTV system with an acoustic system for fish shoal density; and (iii) a commercial aerial scouting system for SWA fisheries.

6.3.1 The South African system

A twin-engined high wing aircraft, equipped with DECCA Navigator and various VHF radios, earches each of four areas in rotation or on an *ad hoc* basis if required (Figure 1). Information on the location of luminescent areas, possible identification and "guesstimates" of onnage are relayed via a private VHF radio link system to a private control centre; from there the information is relayed by marine HF to the fishing vessels. The service is strictly aerial scouting (strategic deployment of the fleet) in order to delineate areas of interest within which sonar equipped vessels are expected to detect, select and catch shoals unaided by the aircraft. With only one aircraft operating, a fishspotting system providing assistance in location of shoals, advice on optimum catching tactics and setting of the purse-seine net leads to discontent among fishermen who do not receive assistance on request.

No fishing vessels have DECCA Navigator, it is primarily a safety feature and easy reference system for the aircraft and its controller.

At night fish are detected with the eye. Identification of species is difficult, there being five pelagic species common in the fishery. On completion of the flight a tabulated description of the results is completed (Figure 2). These data are used to compile time-series of observations and to detect short-term trends in availability and distribution of the various fish species. The system commences operation before the season opens and continues throughout the six-month season.

In most respects the system is similar to the Icelandic herring scouting service described by Jakobsson (1957). Recently a thermal IR radiometer has been used to measure sea surface temperature in order to avoid searching over water with unfavourable surface temperature characteristics, so increasing the effectiveness of expensive search time. This appears to be satisfactory when searching warmer offshore waters for mackerel, but on the whole, interpretation is difficult due to oceanographic conditions (see sub-section 6.4.2).

6.3.2 The South West African system

Traditionally, the industry has not felt the need for a commercial aerial fish detection service, but a scientific system has been operational for some years providing feedback to the industry. The aim is to develop an aerial/acoustic pelagic fish stock inventory system involving a spatially scanning LLLTV system to produce tape-recorded imagery on which computer-aided area measurements can be accomplished, and an acoustic system which measures fish shoal surface density. Together these data can provide estimates of population size within known confidence intervals and determine the distribution of shoals (Hampton, 1975; Cram and Hampton, 1976).

6.3.2.1 Brief technical description of the LLLTV system

The Bosch-Fernseh TV720 camera (28 v.DC) is equipped with a Westinghouse 40:25mm front intensifier (WL 30677) and a Westinghouse 25mm EBS image tube (WL 31972). The front intensifier was selected by the suppliers for its maximum response in the blue/green part of the spectrum. The automatic gain control was changed to manual, but this is not ideal and both options will be replaced. The f1,0 70mm lens was not specified for the system and, though adequate, could be improved upon (Boettcher _et al_., 1974). The field-of-view is 22°. The lens is equipped with bandpass filters designed to transmit bioluminescence and suppress other wave lengths, particularly near infra-red (Boettcher _et al_., 1974a). This increases the signal-to-noise ratio by a factor of about 3.

The camera is installed horizontally beneath the aircraft in a pod (Figure 3). The pod is equipped with a forward motion compensation device consisting of a rocking mirror whose amplitude and rate of rocking can be controlled according to the aircraft's velocity and altitude, and also a device for rotating the camera field-of-view through 180° beneath the aircraft (Malan _et al_., 1977).

The pod has a number of control options: automatic scanning over a chosen angle, direct drive of pod rotation and mirror angle by a joy-stick, forward motion compensation (nadir only), and a "home" position when not in use.

The scanning device allows a wide search path (depending on altitude) and the forward motion compensation device allows very dim shoals to be observed directly beneath the aircraft. The effect of the forward motion compensation device in increasing the signal-to-noise ratio allows a number of options for scientific use, such as electro-optic and computer methods for image enhancement. The use of LLLTV provides the potential for transmitting images to fishir vessels to aid in their catching tactics (Zapata, 1977).

A video-display and video-tape recorder are driven from the aircraft's 24/28 v.DC power via a 220 v.AC 50 Hz inverter. The aircraft most used is twin-engined, high-wing and equipped with DECCA Navigator and supplementary marine HF and VHF radios.

6.3.2.2 Data products and usage

Maximum survey effort is made in the closed season (September to February), although monitoring flights have occasionally occurred during the fishing season.

Data from aerial/acoustic surveys, together with all data from other sources, are incorporated by the Sea Fisheries Branch into a management strategy for the season ahead. These annual forecasts are disseminated by meetings with factory management bodies, boat owners and fishermen's associations, as well as by the South African Shipping News and Fishing Industry Review (e.g., Cram, 1977). The forecasts are used by factories in guiding production strategies, recruitment of labour, deployment of the fishing fleet and setting its initial objectives, and in making decisions on the extent of pre-season stockpiling of cans.

In 1977 the aerial/acoustic/catching survey was most beneficial to the industry in identifying a large population of juvenile pelagic maasbanker, an under-exploited resource and probable growth point. Data products such as distribution maps of bioluminescent areas - with identification, if possible (Figure 4a), distribution of sonar contacts - with identification, if possible (Figure 4b), and experimental catches guided the industry into a successful strategy to optimise their landings of this species while maintaining cannery production of pilchard.

6.3.2.3 Commercial aerial scouting

A commercial aerial scouting system has operated intermittently out of Walvis Bay since 1975. The principal objective is to locate species other than pilchard, as this species is on a restricted quota. The twin-engined low-wing aircraft equipped with DECCA Navigator operates over an extended area with spotters searching with the eye. A written description of the findings and map of the flight path are provided, with which factory managers plan their fleet operating strategies (Figure 5). Attempts are made to use radio communications, but there is no control system and contact with individual vessels is not always possible.

This service has been more efficient in a fishspotting mode when servicing three vessels working from Lüderitz, the minor port in the fishery, than in an aerial scouting mode operating from Walvis Bay.

6.4 Experience and problems with existing systems

6.4.1 Operational considerations

Both the Cape and SWA systems suffer from problems of weather, especially fog and low stratus cloud. In addition, for night flying aircraft, landing fields are very sparse and suitable navigation systems expensive. An aircraft with very substantial endurance is required for safety in the event of weather closing the coastal airstrips and a daylight landing required elsewhere.

6.4.2 Oceanographic problems

Ecological research has not pin-pointed an easily measurable parameter which gives a good key to distribution of pelagic fish (e.g. surface temperature). In addition, the presence of steep, shallow thermoclines is confusing. Despite a high surface temperature which is considered atypical of the required species, shoals are sometimes found beneath the thermocline in a cooler environment. Patterns also change rapidly, so airborne radiometers have not been used as a primary search tool (Figure 6a).

The Maritime Weather Bureau, Youngsfield, Cape Town, issues sea surface temperature charts which are very useful due to the long time-series (1968 onwards), despite the occasionally scanty data and use of uncontrolled measurements. The charts are prepared on the basis of data from ships' weather reports. These data are plotted at the ships' given positions, then every ten days the temperature distribution is subjectively contoured (Figure 6b). These "10-day mean" isotherm maps are useful in that they are produced regularly and are widely circulated. They are not commonly used for predictive purposes, but to explain observed phenomena after the event.

6.4.3 Cost-benefit considerations

No definite study has been made of the Southern African aerial scouting systems, but parallels exist with the fishspotting service provided for the U.S. menhaden fleets studied by Norton (1970). In this fishery 50 percent of aircraft time was involved in search and 50 percent in advisory assistance in setting nets. The annual costs ranged from 8-12 percent of total annual costs of the fleet operations (about U.S.$730,000). In the Cape fishery 110 vessels are serviced by one aircraft scouting continuously; the annual operating costs are approximately $10 million and $0.20 million, respectively, i.e. the aircraft operates at about 2 percent of the fleet costs.

The discrepancy between the costs of these two aerial scouting systems relates to different environmental conditions and methods used. The 61 aircraft assisting the menhaden industry in 1965 worked with probably no more than 150 vessels and were considered essential. Menhaden fleet owners operate in environments generally suitable for light aircraft, and aircraft are an essential element in all aspects of the operations. In the Cape the environment is unfavourable for light aircraft. A larger, much more expensive aircraft is being used to provide the payload necessary for navigation and communications equipment. Opinion is divided on the value of the service. In an analysis of fishing effort in the Cape multispecies fishery (Newman et al., 1974) the results of evaluation of the aerial scouting service were equivocal, and omitted from the report. It seems that the techniques used in the analysis could detect no significant increase in fishing power attributable to the single aircraft scouting system, except where a new offshore fishery for mackerel was commenced with the aid of the aircraft.

The deployment of more aircraft even in a night fishspotting mode would be prohibitively expensive, because the increase in vessel efficiency could not be matched by an overall increase in catch, as the fisheries are restricted by quotas, seasons, boat limitation and factory limitation. The socio-economic problem of removing vessels from the fleet rapidly has worked against more cost-effective catches being made by the remaining vessels.

It is possible that the system may not be the most effective, particularly for offshore mackerel. Day spotting is less efficient than night spotting, but for the same percentage costs four aircraft in the Cape system could not provide the same information as 60 in the U.S. system, which places the information where it is needed, i.e. with the fishermen.

Within the industry the estimates of catches directly attributable to aircraft searches vary between zero and 50 percent although the proportion is more likely to be between 5 and 15 percent. The fleet will not depart for another fishing ground, say 5 to 10 hours away, unless the area has been successfully searched by the aircraft beforehand, particularly in the case of offshore mackerel.

No data are available for the SWA system apart from the general cost of U.S$200 per flying hour. Each flight is usually 5 to 7 hours and 10 to 15 flights per month may be accomplished during the six-month fishing season.

6.5 Potential use of satellite systems

6.5.1 Data from operational satellites

Operational satellites such as NOAA-5 collect sea surface temperature data. However space-borne sensors have problems, especially in coastal upwelling areas (except for microwave radiometers):

- cloud cover may be continuous for extended periods;
- the data are ephemeral and thus required for use immediately. Unless direct reception is available the data are valueless; historical tapes have no commercial value;
- direct reception is costly in both the reception facility and the processing. From our experience with image processing, U.S.$300-500 per analysed, plotted image is a conservative estimate;
- it is difficult and costly to widely disseminate pictorial data on highly transient phenomena, especially when these data may be of questionable value to the coastal fisheries;
- sophisticated industrial management is required to make any use of data on highly transient phenomena.

6.5.2 Data from projected satellites

The ecological problem of being unable to readily typify the preferred habitat of the pelagic fish may be helped by the Coastal Zone Colour Scanner(CZCS) on the satellite Nimbus G which senses ocean colour as well as sea surface temperature. Assuming this is possible, the data may be used to infer the distribution of pelagic fish and possibly to explain distributions observed by other means, but they will probably have no relevance to the daily needs of a South African pelagic fishery.

Many sophisticated systems have been proposed, most requiring satellites, sophisticated communications, data transmission and data displays, all of which are costly, require sophisticated users and are at present more heavily dependent upon cloud-free skies than a light aircraft. No such system is therefore envisaged by the fishery surveillance and advisory systems in southern Africa in the foreseeable future.

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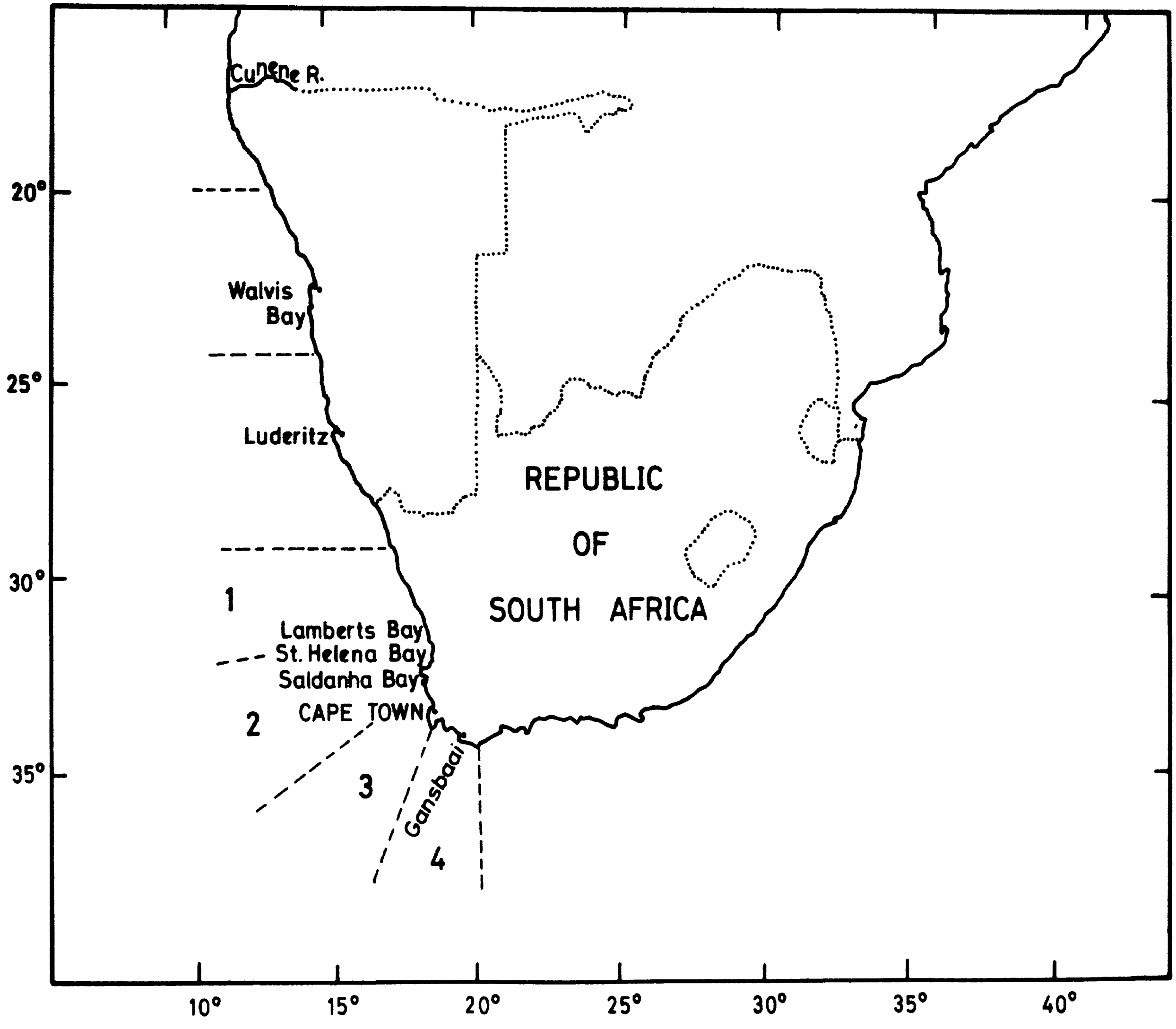

FIG. 1 THE WALVIS BAY AND FOUR CAPE FISHING AREAS

AIR SPOTTING - DAILY FISHING REPORT DATE: 22.3.77.

TIME	DECCA POSITION	POSITION GIVEN TO BOATS	TYPE OF FISH	REMARKS
22.00	F73 & A23	315° - 4NM NORTH HEAD 4810	RED EYE	OVER 2 MILE AREA. WORKING WELL ON LIGHT
22.10	F70 B3	235° - 12NM COL. BINE 3805	ONDERBAADJIE	FISH 5 MILES OFFSHORE) GOOD FIRING
22.12	F66 B6	260° - 9NM COL. BINE 3805	ONDERBAADJIE	) WATER THIS AREA
22.33		270° - 9NM BOB. BERG 3922	RIDEYE/PILCHARD	A FEW KOLLE-WORKING WELL ON LIGHT
22.42	B36 & H70	310° - 5NM KRIEF BAY 3922	PILCHARD/MACK.	GOOD FISH. FROM THIS POSITION
				FISH TOWARDS LAMB. BAY & ALSO
				NORTH WEST. B16 PLATE FISH

FIG. 2 CAPE FISHSPOTTER AND TABULATED DESCRIPTION

FIG. 3: LOW LIGHT LEVEL TELEVISION POD

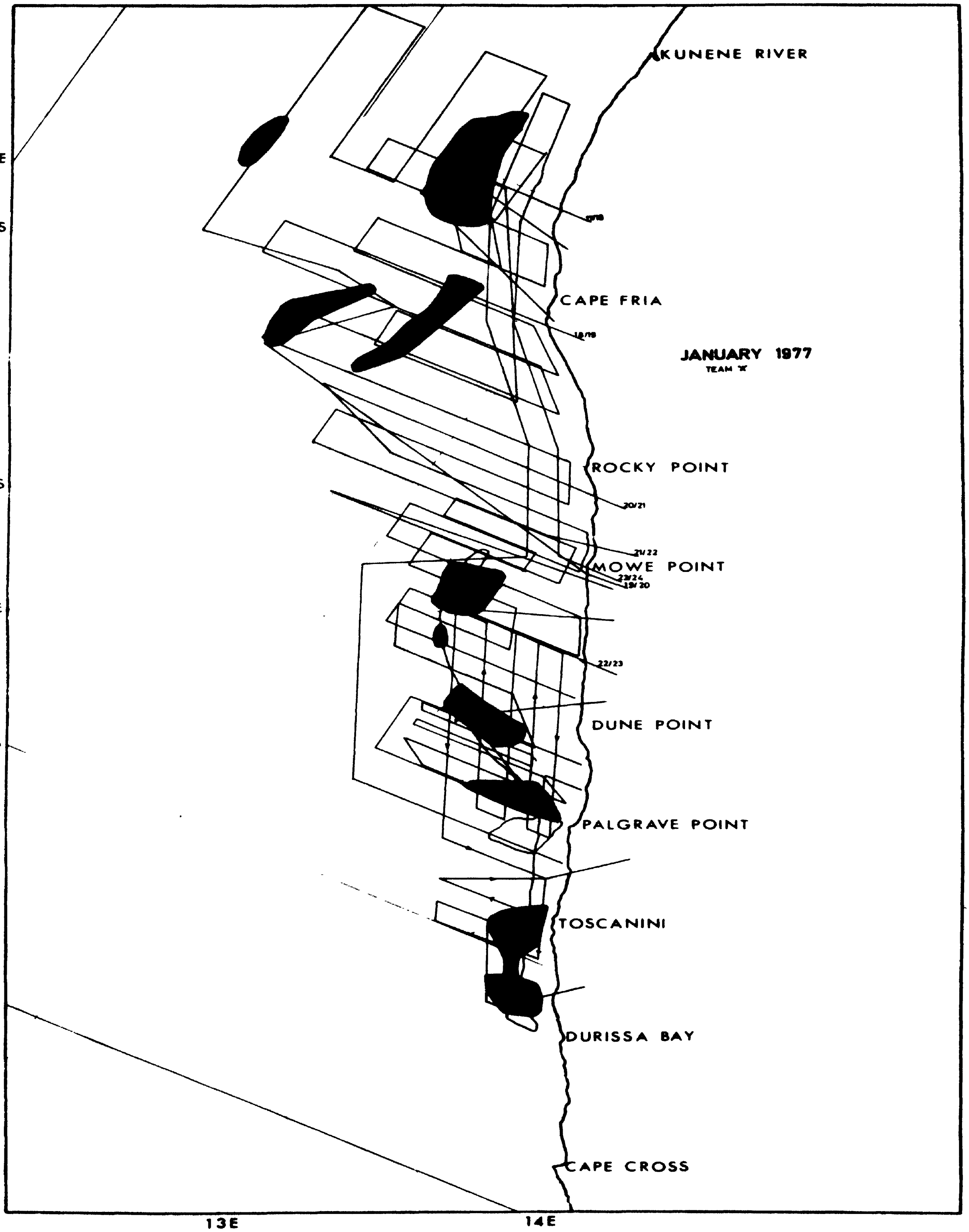

FIG. 4a: AERIAL BIOLUMINESCENCE OBSERVATION

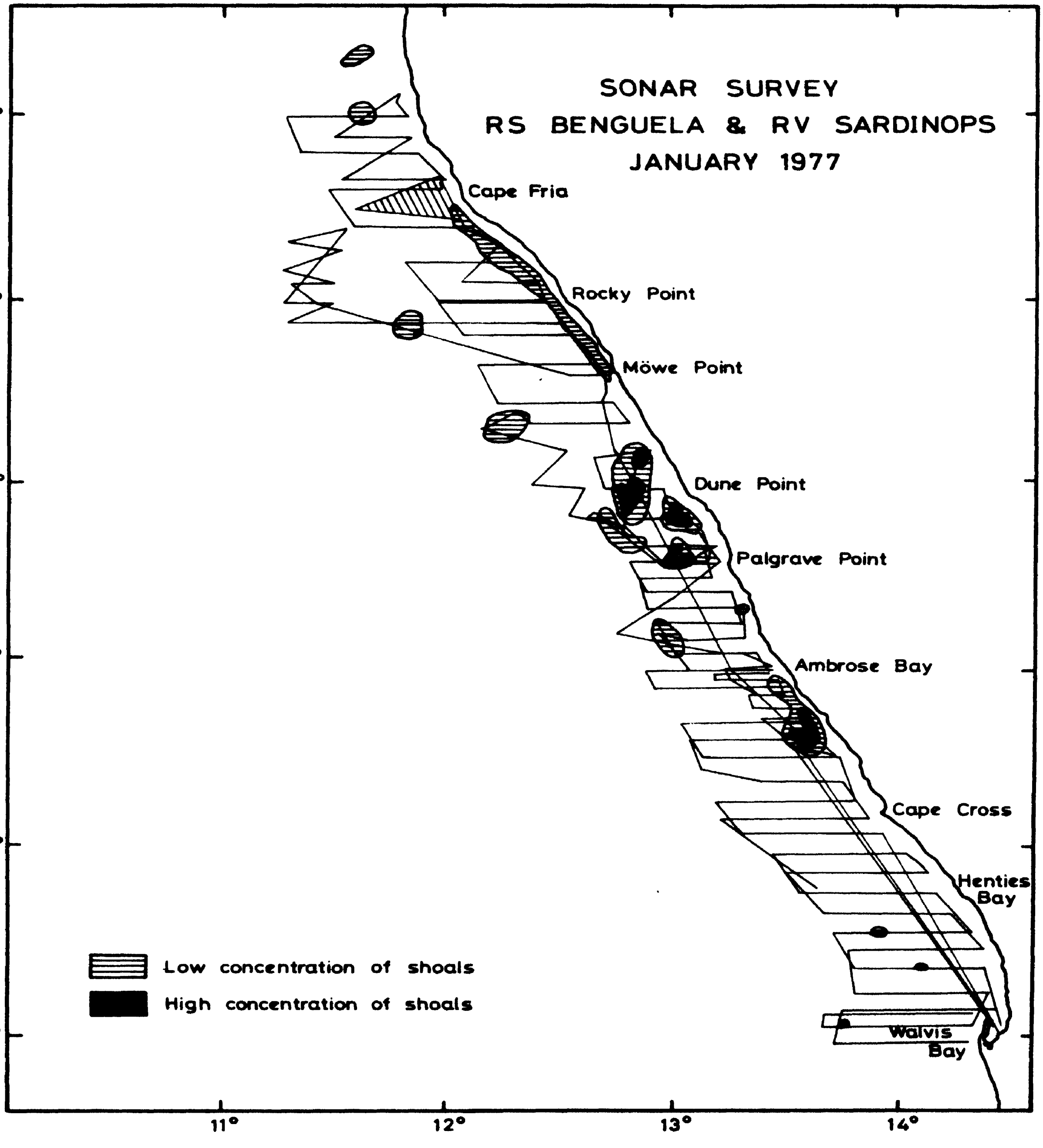

FIG. 4b: SONAR MAPPING

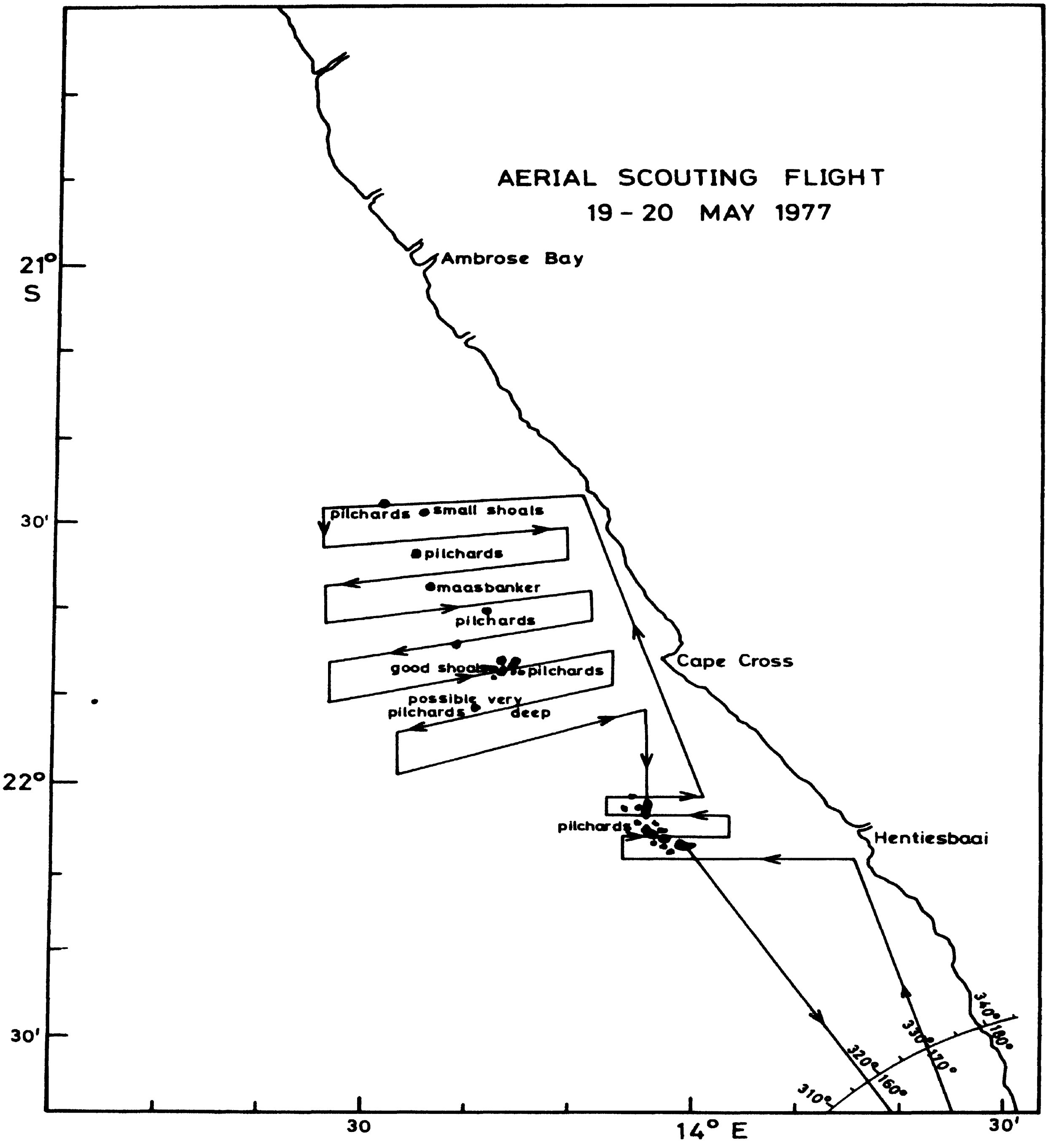

FIG. 5: S.W.A. FISHSPOTTER MAP

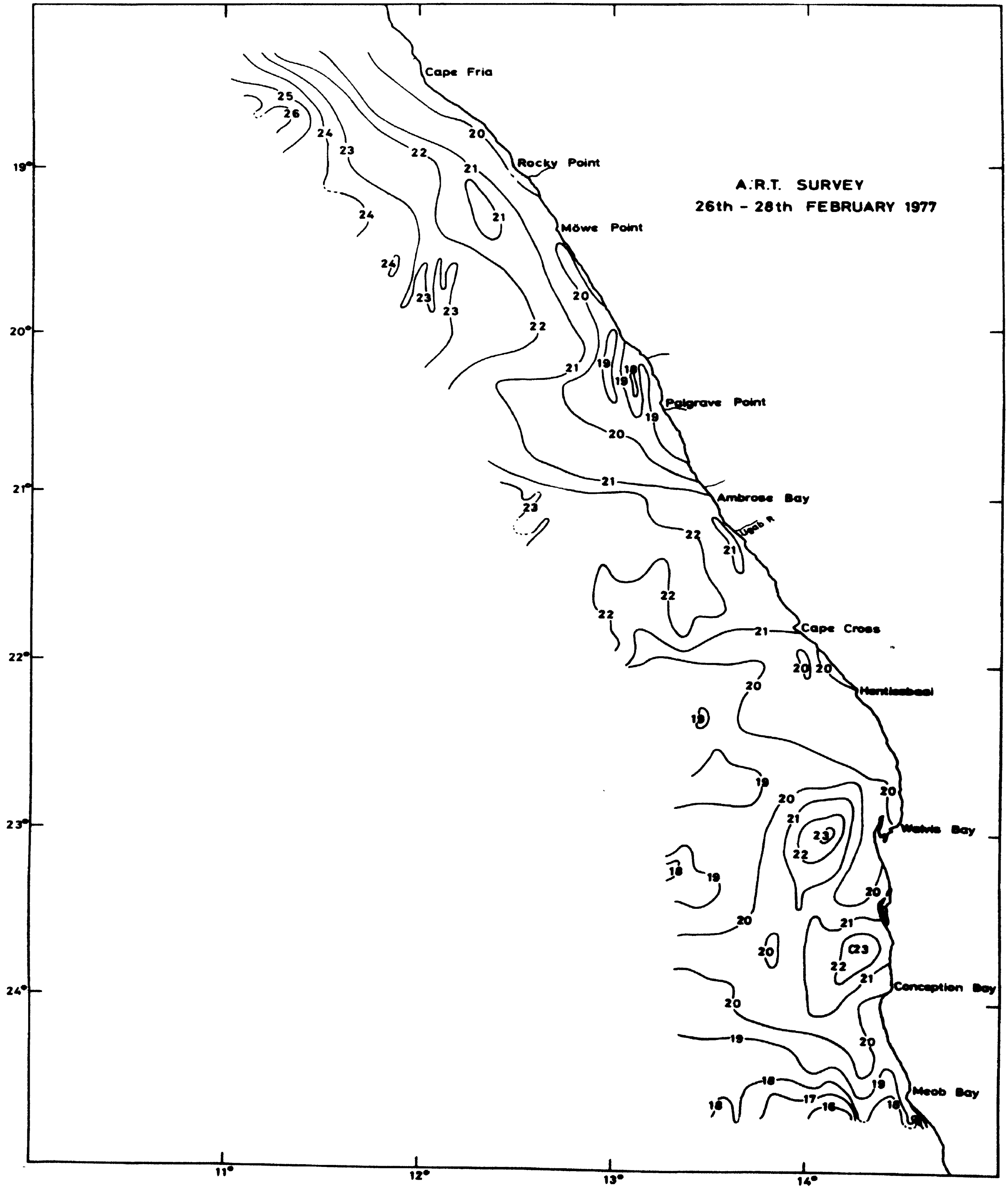

FIG. 6a: ART ISOTHERM MAP

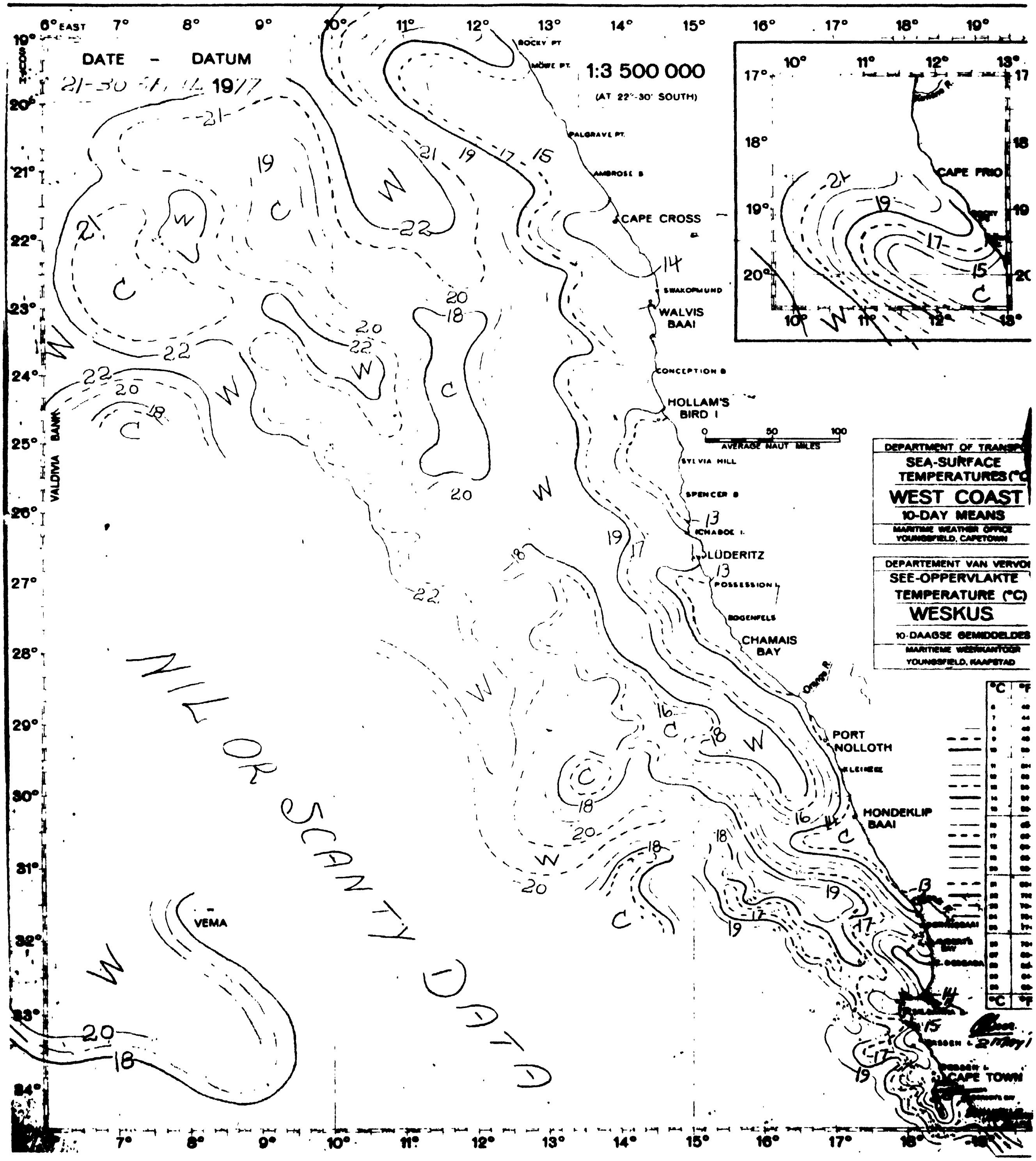

FIG. 6b: MARITIME WEATHER BUREAU "10-DAY-MEAN" ISOTHERM MAP

7. TUNA/ENVIRONMENT PROGRAMMES AT THE SOUTHWEST FISHERIES CENTER, LA JOLLA, Ca., U.S.A.

by

R.H. Evans

7.1 Introduction

Scientists of the Southwest Fisheries Center (SWFC), the Inter-American Tropical Tuna Commission and others have for a number of years studied the effects of the marine environment on the distribution, abundance and availability of tropical and temperate tunas. Much of this work has been essentially descriptive. For example, compilations of catch statistics and the results of tagging experiments have been used to define distribution limits and migration patterns (Schaefer et. al., 1961; Fink and Bayliff, 1970), and atmospheric and oceanic climatology has been used to describe the current structure and water mass characteristics within these limits (Sette, 1955, Owen, 1968). Also, environmental variables such as wind speed, sea surface temperature, mixed layer depth, water colour and dissolved oxygen content have been used as indicators of distribution and availability (Laevastu and Rosa, 1963; Blackburn, 1963; Green, 1967).

These studies have done much to describe the tuna's habitat and behaviour. Further, they have led us closer to the solutions of problems which are of paramount importance in understanding how the environment affects the availability and exploitation of tunas. These problems include:

(i) The complex manner in which atmospheric, oceanic and biological processes interact to affect survival during the larval stages.

(ii) The feedback mechanisms through which these same atmospheric, oceanic and biological processes are modulated in both space and time.

(iii) The manner in which fluctuations of the marine environment, as well as economic and political factors tend to affect the distribution of fishing effort and consequently the size of the resulting harvest.

These problems are the subject of continuing research at the SWFC where recent studies have established the need for a detailed time series of environmental data from the fishing grounds.

Traditionally, environmental data for fisheries research have been collected from cruises aboard research vessels. More recently these same data have been acquired from merchant ships and ships of opportunity. The latter has proved to be the more economical approach, but incoming data still tend to be sporadic in both areal and temporal coverage. SWFC researchers have moved to alleviate this problem by supplementing these traditional sources of environmental data with satellite data and data collected by tuna fishermen on the fishing grounds.

7.2 Background

Fisheries environment related studies at the La Jolla Laboratory take a number of forms but three ongoing programmes stand out because of their cooperative involvement with fishermen and the real-time nature of the data exchanged by the participants. The first programme, the publication of Fishing Information, utilizes "real-time" marine weather observations to create contoured charts of selected environmental variables which are averaged over periods of 15 days and a month. These analyses, together with summary tests are then printed and mailed to fishermen and other interested parties. The second progra

Chart 3 - One degree Celsius contours [1] of mean sea surface temperature for the month from the eastern North Pacific (see Fig. 2). The areal coverage of this analysis: 18°-60°N and 113°-180°W. Mean values of sea surface temperature for selected shore stations along the west coast of North America as well as ocean station "Papa" (5°N and 145°W) are also included.

Chart 4 - One degree Celsius contours of sea surface temperature for the month from the western North Pacific. The areal coverage of this analysis: 15°-60°N and 170°W-115°E.

Chart 5 - Deviation of the sea surface temperature in the eastern North Pacific for the month from the long-term mean 1948-67. Areal coverage of this analysis is identical to Chart 3. The deviation from the long-term mean is contoured at ± 1 degree Celsius intervals.

Chart 6 - Deviation of the sea surface temperature in the western North Pacific for the month from the long-term mean 1948-67. Areal coverage of this analysis is identical to Chart 4 and the contour interval is the same as Chart 5.

Chart 7 - Deviation of the sea surface temperature in the eastern North Pacific for the month from the corresponding sea surface temperature values for the same month of the previous year. The areal coverage of this analysis and the contour interval are the same as Chart 5.

Chart 8 - One degree Celsius contours of sea surface temperature for the month from the eastern tropical Pacific. Areal coverage of this analysis: 30°N-∼30°S [2] and 70°-180°W.

Chart 9 - Deviation of the sea surface temperature in the eastern tropical Pacific for the month from the long-term mean 1948-67. The areal coverage of this analysis is identical to Chart 8. The deviation from the long-term mean is contoured at ± 1 degree Celsius intervals.

Chart 10 - Surface temperature, surface salinity and subsurface temperature structure obtained from expendable bathythermograph (XBT) transects taken between west coast ports in the United States and Hawaii. The data for these analyses come from 4 hourly XBT drops and surface salinity samples collected by cooperating merchant vessels along their scheduled routes. The XBT equipment aboard the vessels is provided and maintained by Pacific Environmental Group personnel stationed at Tiburon, California. The Pacific Environmental Group is a laboratory within the Southwest Fisheries Center.

Charts 11 and 12 - Expendable bathythermograph and surface salinity transects similar to the analyses described in Chart 10. These additional analyses are included in FI when more than one transect is available for the month.

Each month the text and charts that comprise FI are drafted, printed and distributed; the product reaching the subscriber near the end of the month following the analysis. The dissemination of Fishing Information is identical to that for the "supplement".

Each month about 18,000 marine weather observations are used to produce FI. These observations are also used to produce additional environmental data summaries for ongoing research projects of the SWFC and the NORPAX (North Pacific Experiment) at the Scripps Institution of Oceanography. At the end of each month the entire observational data the "Cooperative Tropical Tuna Advisory Programme", utilizes marine weather data and expendable bathythermograph (XBT) data to produce daily weather and sea state charts and weekly sea surface temperature (SST) and mixed layer depth (MLD) charts of the eastern tropical Pacific. These charts are broadcast by radio facsimile (FAX) to cooperating purse-seiners from radio station WWD, a National Marine Fisheries Service licensed radio station in La Jolla, California.

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[1] Sea surface temperatures for the FI monthly publication were changed from Fahrenheit to Celsius starting with the March 1977 issue.

[2] The southern limit of coverage is dependent each month on the amount of sea surface temperature data available in the chart area.

A third programme, the Albacore Advisory Programme, provides weekly SST charts and narrative texts of fishing conditions to albacore fishermen off the west coast of North America. The Albacore Advisory Programme is described in detail in section 8.

Both Fishing Information and the FAX Programme depend heavily on "real-time" weather observations. Internationally formatted marine weather observations are received at the SWFC from Washington, D.C. via a 100-word per minute National Weather Service (NWS) teletype circuit. Each weather observation is then converted to a computer card image suitable for computer processing. At weekly intervals these observations are computer edited to remove duplicate and erroneous observations. The resulting data files are then processed using a suite of computer programmes which create weekly, bi-weekly, and monthly summaries of selected environmental variables.

7.3 Data collection and environmental product preparation

7.3.1 Fishing information

Of the Fishery/Environment related advisory programmes at the SWFC, Fishing Information (FI) is the oldest. FI was started in 1957 at the Honolulu Laboratory of what was then the Bureau of Commercial Fisheries (BCF). Monthly charts of sea surface temperature for the North Pacific were prepared to gain a better understanding of albacore migrations. In 1960 the task of preparing these charts was transferred to the Tuna Forecasting Programme at the La Jolla Laboratory, where they were published in the California Fishery Market News Monthly Summary, Part II. At that time, the project was expanded to include the issuance of a bi-weekly SST chart as well as a monthly plot of average SST's for the eastern tropical Pacific. In ensuing years through 1974, the content of FI was altered frequently in response to user requests. In 1970 the publication was expanded to include SST charts of the western North Pacific. In addition, the 1° square plots of SST in the eastern tropical Pacific were converted to contoured charts of SST.

The current bi-weekly component of FI is a sea surface temperature chart for the eastern North Pacific covering an area from the west coast of North America westward to 136.5°W between 25° and 52°N. At 15 day intervals about 1200 SST observations, averaged by one degree squares, are contoured at two degree Fahrenheit intervals to produce the bi-weekly chart (see Fig.1). This chart, entitled "FISHING INFORMATION - supplement", is then mailed to about 725 subscribers on a "no-cost-to-the-subscriber" basis. The mailing list for the supplemental chart as well as for Fishing Information is presently limited to 750 subscribers.

The parent publication of the supplemental chart is a collection of environmental analyses. FI contains narrative descriptions of current meteorological and oceanographic conditions in the north and eastern tropical Pacific as well as 10 to 12 charts of selected environmental variables for the same areas. The content of these charts is as follows:

Chart 1 - Seventeen-year mean (1961-1977) of observed sea level values of barometric pressure, and (by 5 degree squares) the resultant wind direction, resultant wind speed and average wind speed. The areal coverage of this analysis: 20°-60°N and 115°-180°W.

Chart 2 - Observed sea level values of barometric pressure for the current month; and (by 5 degree squares) the resultant wind direction, resultant wind speed and average wind speed. The areal coverage and format of this analysis is identical to Chart 1.

set as well as certain data summaries are archived on magnetic tape and stored at the SWFC. This data set, which has been maintained since June 1960, forms a unique data source for ongoing studies of the environment and climatology of the Pacific Ocean.

7.3.2 Cooperative Tropical Tuna Advisory (FAX) Programme

By 1970 United States tuna purse-seiners were beginning to range further westward from the coast of Central America in search of yellowfin and skipjack tuna. The offshore fishing areas were outside standard shipping routes and it appeared that the purse-seiners might provide useful information from this "data sparse" region. As a result, the SWFC instituted the Cooperative Tropical Tuna Advisory Programme, designed to foster an exchange of environmental data between tropical tuna fishermen and researchers at the SWFC (Eber, 1976).

To effect this exchange of data, two fundamental problems had to be overcome. The first was how to provide useful environmental information to vessels which routinely remained at sea for periods of 3 months or more. A pilot project in the summer of 1970 demonstrated the feasibility of long range communications between the tuna vessels operating in the eastern tropical pacific and radio station WWD. The project indicated however, that the transmission of large amounts of verbal information by WWD and the assimilation of these data by the tuna seiners was difficult and time consuming.

Radio facsimile appeared to offer a viable means of transmitting the needed data to the tropical tuna fleet in "real-time". In late 1970 three facsimile units that were surplused by the U.S. Navy were obtained and modified to copy radio facsimile transmissions. These units were installed on three XBT equipped purse-seiners during the 1971 fishing season.

The second problem that had to be solved was how to allow the participating vessels to radio positional and environmental data to WWD without revealing their positions to other purse-seiners. Since the tropical tuna fishery is so competitive and covers such a large area of the eastern tropical Pacific, fishermen tend to operate independently or in small groups. The geographical location of these operating units is a closely guarded secret and is considered by many fishermen to be essential to the success of the fishing operation. To allow the cooperating fishermen to keep their position secret it was necessary to devise a coding system for them to use in reporting the position of their observations. This was done by providing each participant with his own unique location code. The use of this code has allowed each vessel to radio XBT and marine weather data to WWD without compromising its location.

The coding scheme is administered by the U.S. Navy's Fleet Numerical Weather Central (FNWC) at Monterey, California. FNWC maintains each vessel's location code in their computer for decoding the participating vessel's geographic position. The computer programme that decodes the vessel's position outputs the data without including any vessel identification. This ensures the confidentiality of the vessel's location in all instances.

To implement this decoding scheme, environmental observations radioed to WWD by the participants are relayed to the SWFC via teletype (see Fig. 3). The observations are then transmitted to FNWC over the Navy Environmental Data Network tieline. After decoding at FNWC, the XBT and marine weather observations from the participating vessels are returned to the SWFC in decoded form. These observations are also sent via teletype from FNWC to the National Weather Service Forecast Center at Redwood City, California.

Currently WWD collects XBT and marine weather observations from the participating vessels between the hours of 2200 and 2300 GMT. These data, as well as environmental products from FNWC, the National Weather Service and APT (Automatic Picture Taking) satellite photos are utilised by the SWFC staff to create analyses for broadcast to the participating vessels. Initially, two products - the wind and weather analysis and the sea state analysis-were broadcast daily (Monday through Friday) at 2300 and 2310 GMT each day. A third chart, the weekly mean sea surface temperature analysis, was added for broadcast each Thursday at 2320 GMT (Fig. 4). A summation of all of the environmental advisories currently offered by radio station WWD is included in Table 1.

During the past six years the format and content of the FAX products offered to the participants has varied in response to user needs. A verbal advisory describing tropical storms or areas of high winds now accompanies the facsimile charts when conditions warrant. In January of 1973 a weekly mean mixed layer depth analysis (see Fig. 5) was added for broadcast at 2320 GMT each Friday. In April of 1974, the National Weather Service Forecast Center (NWSFC) in Redwood City, California became a participant in the programme by providing the wind and weather and sea state analyses for broadcast by WWD on weekends (see Fig. 3). In August of 1974 the NWSFC assumed responsibility for the preparation of these two charts. At present, the wind and weather and sea state advisories are being offered by the NWSFC through WWD twice daily, seven days a week (see Table 1).

As indicated, the services offered by the Tropical Tuna Advisory Programme have expanded dramatically since 1971. No less dramatic has been the expansion in the number of participants and the data they have provided to the SWFC. During 1971, FAX units owned and maintained by the SWFC were installed on a total of 25 purse-seiners. These participants radioed 1528 weather and XBT observations to WWD. By the end of 1975 the number of programme participants had risen to 75, who contributed 7653 environmental observations during the year. To date, more than 30,000 observations have been received, utilized and archived at the SWFC.

7.4 Programme effectiveness

An analysis of the effectiveness of the FI and FAX programmes is complicated by the fact that these are cooperative programmes that are of benefit to fishermen and researchers alike. In light of this, we must first consider the utility of the information provided to the user of environmental products, basically the fishermen. Second, we must consider the contributions to fishery-environment research that are realised from the "real-time" data and various information from the fishermen. The analysis, however, at the present time must rely on primarily qualitative rather than quantitative standards because data on a "real" value of the information to the research or fishermen have not been gathered.

Several attempts have been made by the SWFC to evaluate the utility of FI. In 1967, 1974 and 1975, surveys were conducted to characterise the subscribers and how they used the FI charts and text. In the 1975 poll, to which 548 subscribers responded, the largest single user group (33%) were commercial fishermen. Of this group, 92.1% indicated that the FI products were used in developing their fishing strategy and 77.3% indicated that the sea surface temperature charts were the most useful information contained in the publications. Of the two FI publications (monthly and bi-weekly supplement), the bi-weekly publication (see Fig. 1) was favoured over the monthly publication.

In addition to commercial fishermen, FI is also used by sport fishermen, fish processors, fisheries researchers, oceanographers, and meteorologists. Respondents in these categories indicated that the FI products were most useful in environmental and fishery research, respectively. Again the SST charts were indicated as being the most useful.

The FI programme also provides information in the form of processed data and data summaries for fisheries and marine environment research. Researchers at the SWFC, the Scripps Institution of Oceanography and elsewhere routinely use the FI databases for monitoring long-term sea surface temperature anomalies and ocean-atmosphere heat exchang fluctuations. The FI data have also been used for locating ocean frontal boundaries and as ground truth for satellite derived SST values. In fact, the FI data base is unique in that it is the only readily available source of quasi-current information on abnormal ocean conditions, such as El Niño occurrences, for the eastern Pacific.

Attempts have also been made to evaluate the utility of the FAX programme to tropical tuna fishermen. During 1973 and 1974, 22 tuna purse-seine skippers were interviewed by SWFC staff members. Nearly all of those interviewed indicated that they copied the FAX charts daily and also listened to the verbal advisories. The fishermen indicated that the wind and weather sea state charts were of the greatest use to them. These charts allowed them to fish in the productive areas along the Inter-Tropical Convergence Zone while avoiding the tropical cyclones that frequent the area during the summer months. They also indicated that the SST and MLD charts were useful in the development of fishing strategy and day-to-day tactics.

Further information concerning the utility of the FAX charts has been obtained at annual meetings where tuna fishermen and SWFC researchers gather to discuss the FAX programme and suggest ways to improve it. These meetings, which have been held each December since 1972, provide a forum for an interchange of ideas concerning the content of the FAX advisories and the programme in general. In this way advisories of the greatest potential use to the fishermen are ensured.

In conclusion, it is impossible to state unequivocally that FI and the FAX programme are "cost effective" or have a profound influence on the cost of fish at the market place. We can only surmise from the existing information that these programmes are important to fishermen and of value to the research community.

7.5 References

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Table 1

Synopsis of Fishery-Environment Products Offered by the Southwest Fisheries Center through Radio Station WWD

Type of Product	Mode of Dissemination*	Broadcast Frequency	Frequency of issue	Time of Issue (GMT)	Product Valid Time (GMT)	Areal Coverage	Product Originator	Prime User	Product Content
1. Wind & weather analysis and forecast	Radio facsimile	8644.1 & 17,408.6 kHz	Daily	1500 2300	0600 1800	From the west coast of N&S America to 160°W between 20°S and 37°N	National Weather Service	Tropical Tuna Fleet	Wind speed, wind direction, position of the Inter-Tropical Convergence Zone (ITCZ), cloud cover, positions of severe weather, initial and forecast positions of tropical disturbances.
2. Sea & swell analysis & forecast	Same	Same	Same	2310	1800	Same	Same	Same	Wave height, swell height, swell direction, swell period, and areas of rough seas.
3. Weekly mean sea surface temperature analysis (tropical area)	Same	Same	Weekly on Thursday	2320	Previous 7-day period	From the west coast of N&S America to 140°W between 6°S and 30°N	Southwest Fisheries Center	Same	Weekly mean sea surface temperature (SST) isotherms derived from weekly 1° square averages of SST. Contour interval 1°C with areas of sparse data coverage indicated by dashed contours.
4. Weekly mean mixed layer depth analysis (tropical area)	Same	Same	Weekly on Friday	2320	Same	Same	Same	Same	Weekly mean mixed layer depth (MLD) derived from energy numerical models, computed for 5° squares. The results are hand contoured at 50 foot depth intervals. Areas of sparse data are indicated by dashed contours.
5. Tropical storm advisories	Verbal broadcasts	Same	As required	1510 2310	As indicated in broadcast	Same	Same	Same	Information concerning tropical storms or other areas of inclement weather. The broadcasts contain present and forecast positions of storms, areal extent, expected winds, direction and speed of the storm, pertinent sea state information, and other information as required.
6. Weekly mean sea surface temperature analysis	Radio facsimile	Same	Weekly on Friday during albacore season (∿July-Oct.)	1700	Same	From the west coast of N. America to 141°W between 28° and 52°N	Same	Albacore fishermen	Weekly mean sea surface temperature (SST) isotherms derived from weekly 1° square averages of SST and hand contoured. Contoured interval 1°C.

*All broadcasts from radio station WWD are upper sideband carrier frequencies. The facsimile scan rate is 120 lines/minute with an international index of cooperation of 576.

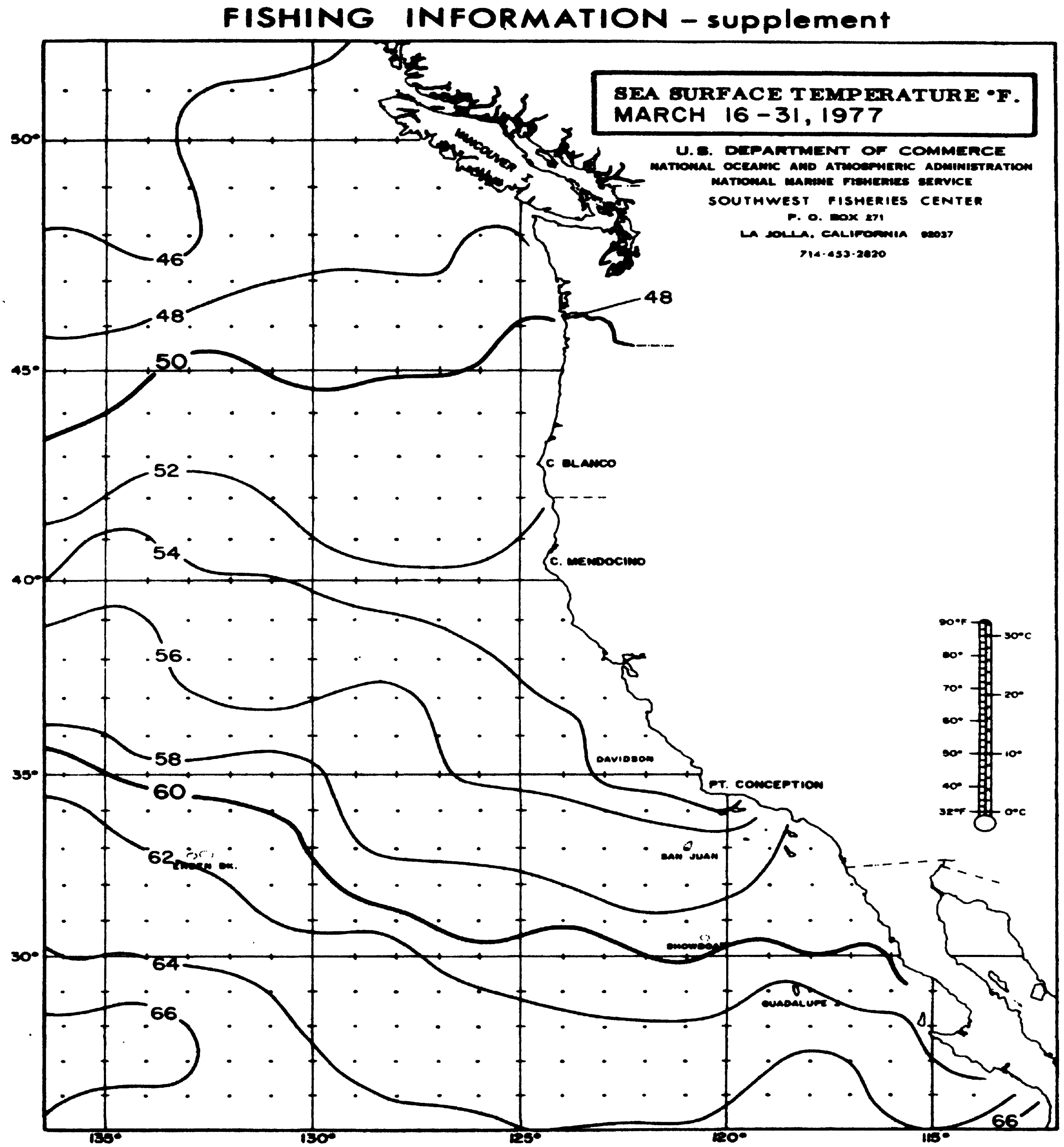

Figure 1: Example of biweekly SST chart distributed to albacore fishermen

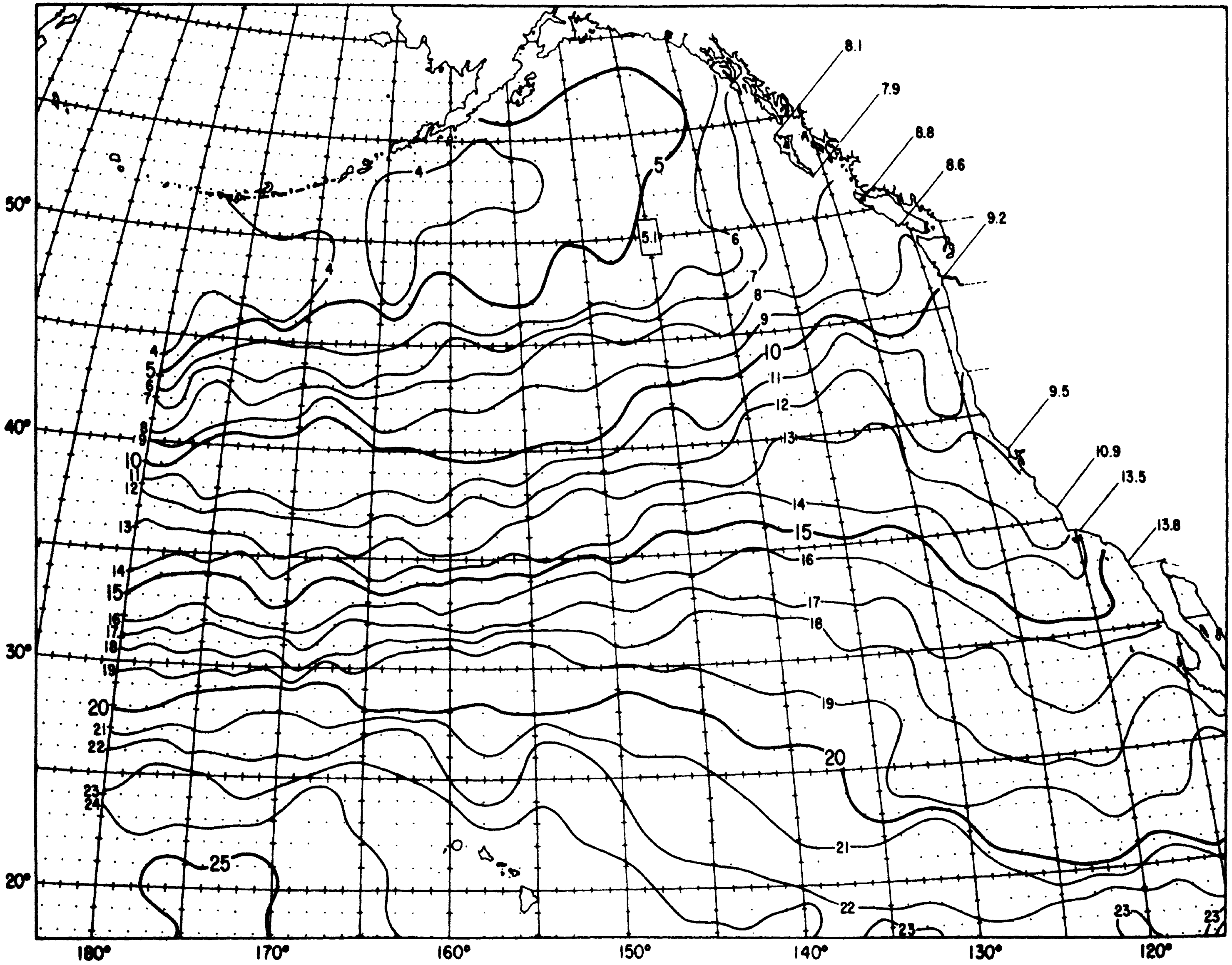

Figure 2: Example of a mean sea surface temperature map (month of March 1977)

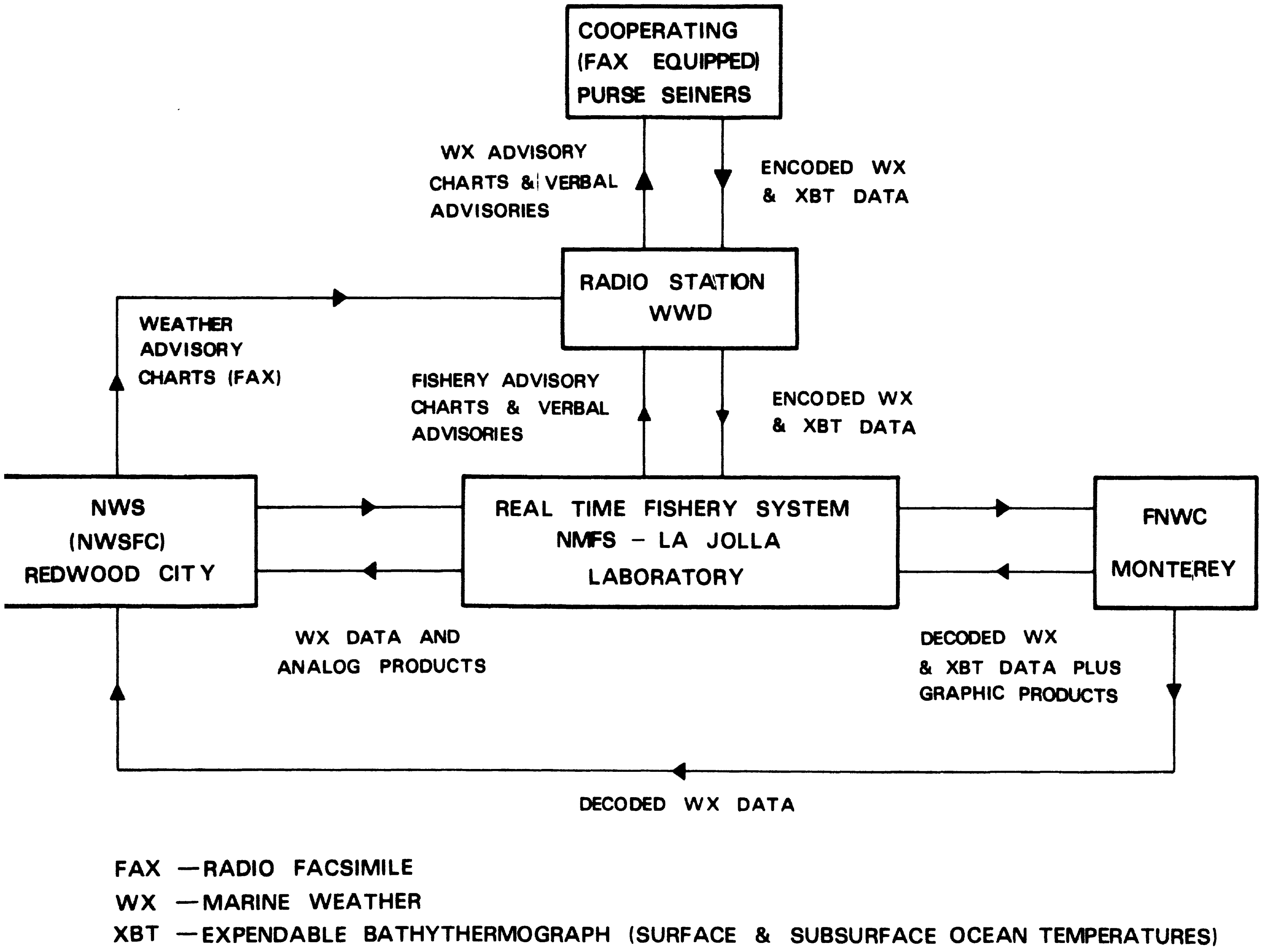
COOPERATING (FAX EQUIPPED) PURSE SEINERS
WX ADVISORY CHARTS & VERBAL ADVISORIES
ENCODED WX & XBT DATA
RADIO STATION WWD
WEATHER ADVISORY CHARTS (FAX)
FISHERY ADVISORY CHARTS & VERBAL ADVISORIES
ENCODED WX & XBT DATA
NWS (NWSFC) REDWOOD CITY
REAL TIME FISHERY SYSTEM NMFS – LA JOLLA LABORATORY
FNWC MONTEREY
WX DATA AND ANALOG PRODUCTS
DECODED WX & XBT DATA PLUS GRAPHIC PRODUCTS
DECODED WX DATA
FAX —RADIO FACSIMILE
WX —MARINE WEATHER
XBT —EXPENDABLE BATHYTHERMOGRAPH (SURFACE & SUBSURFACE OCEAN TEMPERATURES)

Figure 3: Flow of information within the NMFS Cooperative Tropical Tuna Advisory Program

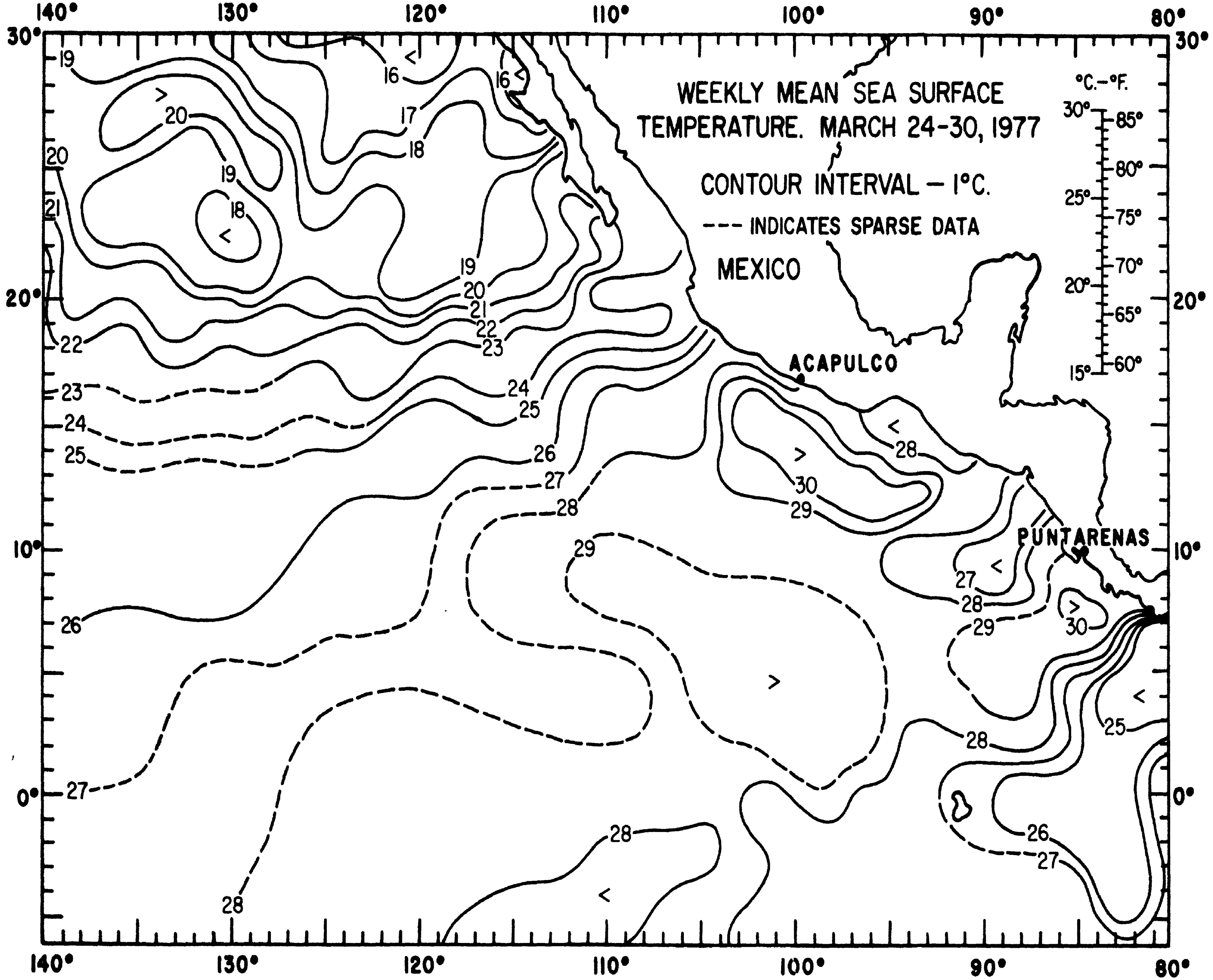

FIG. 4: U.S. DEPARTMENT OF COMMERCE, NOAA NATIONAL MARINE FISHERIES SERVICE, FOC La Jolla, Calif.

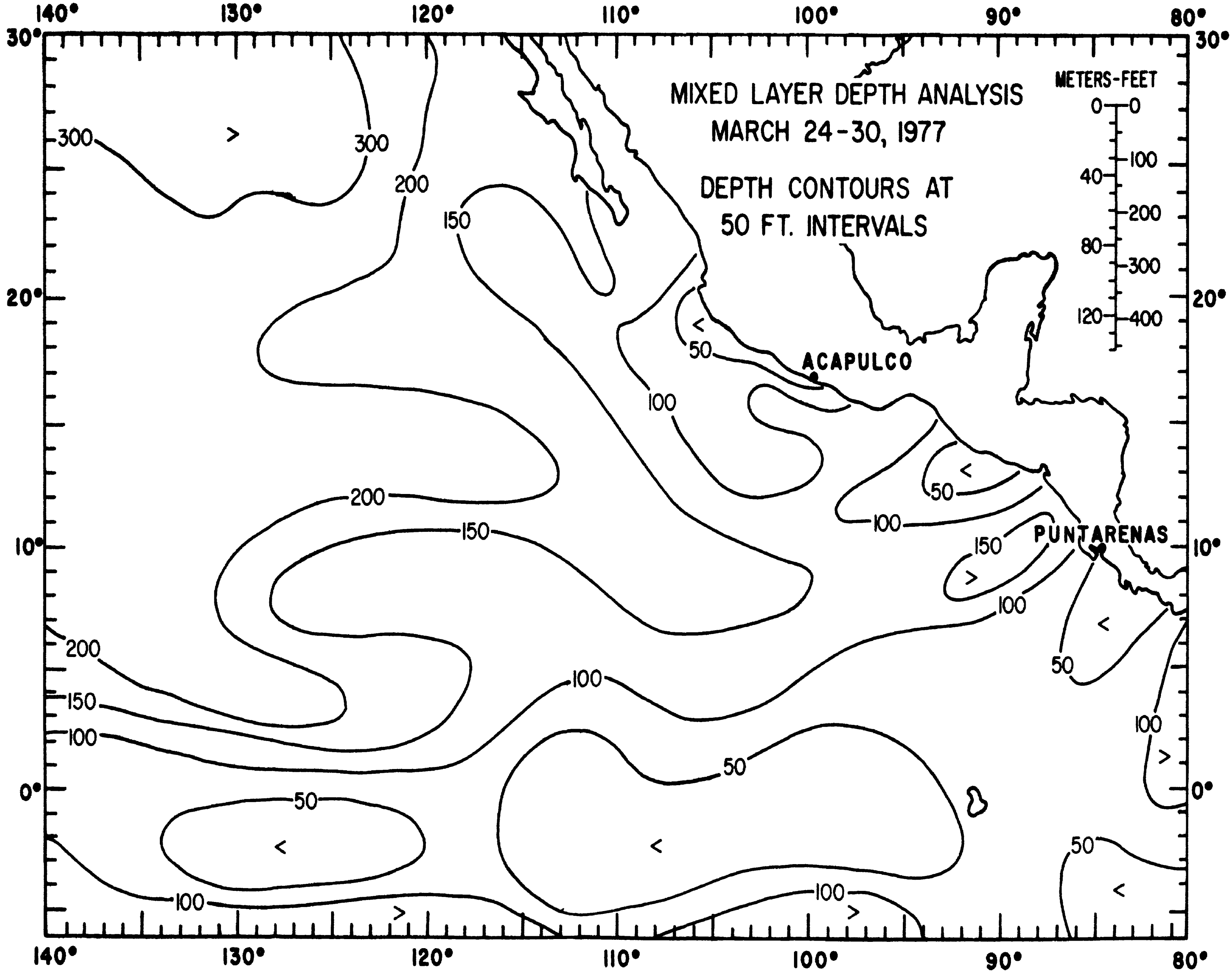

FIG. 5: U.S. DEPARTMENT OF COMMERCE, NOAA NATIONAL MARINE FISHERIES SERVICE, FOC La Jolla, Calif.

8. ALBACORE ADVISORY PROGRAMME AT THE SOUTHWEST FISHERIES CENTER, LA JOLLA, Ca., U.S.A.

by

R.M. Laurs

8.1 Introduction

The National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA/NMFS), La Jolla Laboratory (and predecessor organizations) has operated an albacore fishery forecasting/advisory services programme since the early 1960's. For the past several years this programme has been a sub-unit of a multidisciplinary research programme on North Pacific albacore, intended to develop optimal management policy recommendations with respect to U.S. interests in North Pacific albacore fisheries and to produce information for optimal planning and operating decisions in the U.S. albacore industry.

8.2 Users of fishery forecast/advisory materials

The users of the albacore fishery forecasting/monitoring services are many and varied. Strategic forecast materials are being used by

- the commercial albacore fishing industry, especially the fish processing and wholesaling components, and operators and owners of fishing vessels or fleets of fishing vessels;
- the recreational fishing community, notably operators of charter boats;
- the management agencies of the State and (potentially) Federal governments.

Tactical fishery forecasting/monitoring materials are used mainly by

- the U.S. albacore jigfishing and baitboat fishing fleets, fish buying stations and other components of the industry;
- recreational albacore fishermen;
- resource managers

The needs of the U.S. albacore tuna fishing industry and fishery managers for strategic and tactical fishery forecasting/monitoring services have been specified through dialogues with members of various components of the industry and fishery scientists, and in literature. A re-evaluation of the needs of the user groups is periodically required due to changes in the fisheries for North Pacific albacore. For example, information on fleet allocation will no doubt need to be added to the strategic list of needs of the U.S. industry.

The strategic needs of all user groups are on time-scales of up to several forthcoming seasons and on an ocean-area basis space-scale. The strategic needs include: (i) the general area in which the stock of fish will be available in the forthcoming season relative to its area of availability in the long-term, specifically the seasonal geographic location of centers of the fishery, e.g., north-south and nearshore-offshore; (ii) range of the fishery in time and space; (iii) the probable level of abundance of the stock of fish over the fishery area in the forthcoming season, relative to its long-term abundance; (iv) variation in expected size composition of fish; (v) the probable long-term oceanographic conditions which may affect fishing operations due to predicted broad-scale anomalies, specifically information on general ocean surface and subsurface temperature conditions; and (vi) the probable long-term wind and sea conditions which may affect fishing operations by broad area due to predicted climatic anomalies.

The tactical needs of all the user groups are similar to the strategic needs, but on time-scales of a few days or weeks and on a "local" area space-scale.

8.3 Albacore fishery forecast advisory/materials

8.3.1 Seasonal forecast

The seasonal forecast is issued in early June about 4 to 6 weeks before the usual beginning of the fishing season. The basic elements of the forecast include a) the proportions of the total catch that are expected to be caught off the Pacific Northwest and off California (north and south of San Franciso), b) an account of trends in oceanographic and atmospheric conditions as they pertain to "set-up" conditions for the forthcoming season, c) long-range outlook of oceanographic, atmospheric and weather conditions that may affect the fishery, and d) information on the catches and landings by state for prior and recent years.

The prediction of the percentages of the seasonal catch expected to be taken north and south of San Francisco is based on an index which qualitatively relates the north-south geographic distribution of albacore catch with oceanographic conditions during spring months in offshore waters through which albacore immigrate to the North American West Coast. In addition, relationships between geographic shifts in the fishery, including ooeanographic frontal boundary features, geographic trends in catch and, to a lesser degree, the nearshore ocean conditions and projected distribution of atmospheric conditions are used. The discussions of trends in oceanographic and atmospheric conditions are based on analyses conducted at the La Jolla Laboratory. The long-range outlook for oceanographic conditions that may affect the fishery is based on an evaluation of recent trends in broad-scale anomaly patterns and the probable effects that the long-range atmospheric conditions will have on oceanographic conditions. The projection of long-range weather conditions is obtained from the National Weather Service.

8.3.2 Biweekly fish bulletins

Albacore fish bulletins (Figure 1a and b) are issued in conjunction with 15-day sea surface temperature charts (see below). Included in the bulletins are short-term projections of albacore distribution and locations of productive fishing areas, information on oceanographic and meteorological conditions, and other information as appropriate. The bulletins are mailed to fishermen and others upon request and are bulk-mailed to fish buyers and processors for further dissemination to fishermen. The bulletins are based on fishery information radioed ashore from cooperating fishermen, from fish buyers and processors, fishermen's associations, and State fishery agencies. Oceanographic information is based on analysis of ocean conditions conducted at the La Jolla Laboratory and an extended weather forecast is provided by the National Weather Service.

8.3.3 Albacore fishing information daily forecasts

Daily broadcasts of albacore fishing information are prepared by the La Jolla Laboratory staff and transmitted to the fishing fleet at sea. The broadcasts include the latest albacore fishing information obtained from research vessels, cooperating fishing vessels, unloading station operators, processors, fishermen's foundations and State fishery agencies. Highlights include location of active centres of fishing, typical fishing scores, size of fish, sea surface temperature and subsurface temperature information when available, and other information as appropriate. A weather and sea state summary prepared by the National Weather Service is also given, including large-scale weather features, regional wind, weather and sea state conditions between 20-250 miles offshore, and storm development. The broadcasts are made twice daily on weekdays and once on Saturday mornings during the albacore fishing season. The broadcasts are transmitted by radio station WWD which is licensed to the National Marine Fisheries Service and Coast Guard radio station NMC on several single side band frequencies and by a number of commercial radio stations along the U.S. Pacific coast on commercial AM frequencies.

8.3.4 Oceanographic advisory information

(i) Biweekly sea surface temperature (SST) charts

The biweekly SST charts cover the area between central Baja California, Mexico and Vancouver Island, British Columbia, Canada out to 135°W (see R.H. Evans, section 7, Figure 1). The SST charts are distributed year-round, but during the albacore fishing season, from about July through October, they are included with the Albacore Fish Bulletins described in section 8.3.2. R.H. Evans gives additional information concerning the SST charts.

(ii) Weekly sea surface temperature (SST) charts

The weekly SST charts cover the same area as the biweekly charts and are transmitted by radio station WWD via radiofacsimile to albacore fishing vessels on the fishing grounds each Friday during the fishing season. Approximately 25 albacore vessels are fitted with radiofacsimile recording equipment. These vessels often pass information on SST gained from the charts to other vessels via voice radio communication.

8.4 Additional information

8.4.1 Vertical sections of ocean temperature

Vertical profiles of ocean temperature and surface temperature and salinity observed between the U.S. west coast and Hawaii (Figures 2a and 2b)have application to the U.S. albacore fishery. The subsurface temperature structure is made from expendable bathythermograph (XBT) drops by cooperating merchant vessels; surface temperature and salinity observations are also made at each XBT station[1] (Saurs and Stevens 1972). The charts are published monthly in *Fishing Information*. In recent years there has been an expansion in the albacore fishery to much farther offshore and about 2 months earlier than the historical start of the fishing season. Fishermen have used the vertical thermal profiles and accompanying information to assist in planning strategy for fishing in the offshore waters during the early season. The isotherms between 16° and 19°C are shaded as an aid to follow variations in distribution of these isotherms which are within the habitat temperature preference for albacore. The charts can also be used to locate oceanic boundary features where the relative abundance of albacore has been found to be high in offshore waters (Laurs and Lynn, in press).

8.4.2 Charts of nominal CPUE and size composition

As an incentive for fishermen to keep logbooks, charts showing nominal catch per unit effort summarized by 15-day period and 1° quadrangle (Figure 3) and size composition by area (Figure 4) for the preceding season are distributed to fishermen with logbooks for use during the forthcoming season. The charts are issued as cooperative products of the state fishery agencies and NMFS. The processing, standardization, and management of a uniform U.S. West Coast logbook for albacore (Laurs, Hooker, Hreha, and Lincoln, 1975) are shared by the states and NMFS. Processing, including editing and quality control, is accomplished by state fishery personnel. The data from each of the states are then made available to the La Jolla Laboratory in ADP form. NMFS scientists merge the data from the states, and the fishing effort is standardized using a modified version of the computer programme FPOW (Berude and Abramson, 1972) as described by Laurs, Clemens, and Hreha (1976).

Comments received from fishermen indicate satisfaction with the CPUE and size composition charts. According to some fishermen, they are more conscientious in keeping logbooks because of the receipt of the catch charts.

[1] Data are processed under supervision of personnel at NMFS Pacific Environmental Group, Monterey, California, using computer facilities of the Navy Fleet Numerical Weather Central, Monterey, California. The project is partially supported by the National Science Foundation and Office of Naval Research

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U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
La Jolla, California 92038

Bulletin No. 77-3

ALBACORE FISHING SCATTERED AND MOSTLY IN SOUTHERN AREAS

Two jigboats in transit from Hawaii to the North American coast were able to locate commercial quantities of albacore near 35°N lat., 135°W long. during early July. For approximately 8 days these boats averaged 150-300 fish per day on predominantly 12-14 pound (5.5-6.4 kg) albacore. These fish are believed to be migrating into the North American fishery. In other areas, fishing was generally scattered and spotty during the first 2 weeks of July. Jigboats fishing in the Guadalupe Island-San Martin Island area averaged 20-40 fish a day with a few high scores of up to 150 fish. Fishing in other areas was also spotty and located farther than 100 miles from shore. Boats worked from San Juan Seamount to the Columbia River with only a few catches greater than 100 fish reported from California waters. Only a few small catches were made north of Cape Blanco. Most of the fish caught north of the San Juan Seamount were 11-13 pounds (5-5.9 kg).

Although baitboat catches were not heard on a daily basis from Baja California, some of these boats were reported to have made catches of 4-5 tons on some days.

On July 18, all three of the American Fishermen's Research Foundation's (AFRF) chartered jigboats were at sea. The Lady Olga worked the San Juan Seamount area from July 1-5 and reported small catches of albacore which averaged 7-12 pounds (3.2-5.5 kg) in sea-surface temperatures of 59.5-62.5°F (15.3-17.0°C). The Lady Olga was in port between July 6-10. Since returning to sea, she has fished from southwest of Point Arguello to Morro Bay. Her best catch averaging 12 pounds (5.5 kg) was 140 albacore taken 200 miles west of Morro Bay in waters with sea-surface temperatures approximately 59°F (15.0°C). The Lusty left Ventura, California on July 5 and worked northward to Cape Flattery. The Lusty reported small catches near the Davidson Seamount and small, scattered catches off Point Arena and northward. Its best days of fishing were on July 11-12 when 41 and 59 albacore were caught from approximately 100-110 miles west of Point Arena. These fish averaged 12½-13 pounds (5.7-5.9 kg) and the sea-surface temperature was about 59°F (15.0°C). The third AFRF chartered jigboat, Four C's, left Astoria on July 13 and fished offshore to Cobb Seamount and off Newport, Oregon. The Four C's has caught only two albacore.

The Oregon Department of Fish and Wildlife also chartered a jigboat to scout the areas off Oregon during part of the first 2 weeks of July; however, no albacore were caught.

Catches made by San Diego based sportboats have ranged from less than one fish per passenger to better than three fish per passenger during the first 2 weeks of July. These boats generally fished from 60-90 miles south of San Diego, with the best catches in the second week of July being made in an area about 60 miles south of San Diego.

Sea-surface temperatures (SST) warmed from July 1-15 over the offshore areas of the eastern Pacific (see chart) at near-normal rates. Along the coast near Cape Blanco and east of 126°W, the 15-day warming trend was 1-2°F above normal and west of San Francisco between 124°W and 125°W, the SST's actually cooled 1-2° more than normal during the first half of July. The cooling of SST's west of San Francisco was associated with frequent periods of strong northerly winds and heavy mixing of colder, upwelled water from the coast. Near Cape Blanco the light winds and relative clear skies from July 1-15 resulted in more surface heating and less ocean mixing and upwelling than normal.

During the last half of July, based on the National Weather Service forecast of slightly above-normal surface pressures centered near 40°N, 140°W, it appears that off shore there will be a near-normal warming trend in SST's. However, south of Cape Mendocino and east of 125°W, SST's have been 1-2°F below normal during the past 15 days. It is expected that SST's will remain more than 1°F below normal in this area, especially within 100 miles of the coast where wind mixing and upwelling are expected to be most pronounced during the latter half of July. The areas with greatest warming of 1-2°F above normal will continue to be north of Cape Blanco from 50 to 200 miles off shore. This area is shown in the attached SST chart where the 56°F and 58°F isotherms bulge to the northeast.

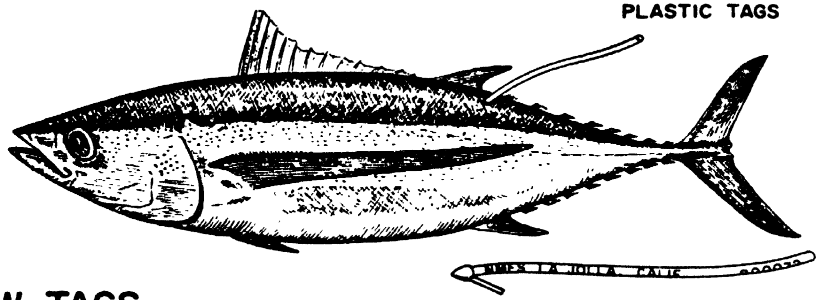
July 18, 1977

Staff, Albacore Fisheries Program
R. Michael Laurs, Leader

Figure 1a. Example of biweekly albacore Fish Bulletin.

$ REWARD $

FOR ALBACORE TUNA TAGS



YELLOW TAGS

THE NATIONAL MARINE FISHERIES SERVICE WILL PAY $ 2.00 FOR EACH YELLOW TAG RECOVERED. (NO NEED TO RETURN FISH)

RECORD:
- ▶ WHERE } FISH WAS CAUGHT
- ▶ WHEN } FISH WAS CAUGHT
- ▶ HOW } FISH WAS CAUGHT
- ▶ LENGTH OF FISH (TIP OF LOWER JAW TO FORK OF TAIL)

FORWARD TO NMFS ADDRESS ON TAG

RED TAGS

THE NATIONAL MARINE FISHERIES SERVICE WILL PAY $ 50.00 FOR EACH RED TAG & FISH RETURNED. (FISH WITH TAG INTACT MUST BE RETURNED)

RECORD:
- ▶ WHERE } FISH WAS CAUGHT
- ▶ WHEN } FISH WAS CAUGHT
- ▶ HOW } FISH WAS CAUGHT
- ▶ LENGTH OF FISH (TIP OF LOWER JAW TO FORK OF TAIL)

NOTIFY NMFS P.O. BOX 271, LA JOLLA, CA. TEL. (714) 453-2820

THE AMERICAN FISHERMEN'S RESEARCH FOUNDATION WILL AWARD CASH PRIZES FOR YELLOW & RED TAG NUMBERS DRAWN IN AN ANNUAL LOTTERY.

Figure 1b. Albacore tagging information included with biweekly Fish Bulletin.

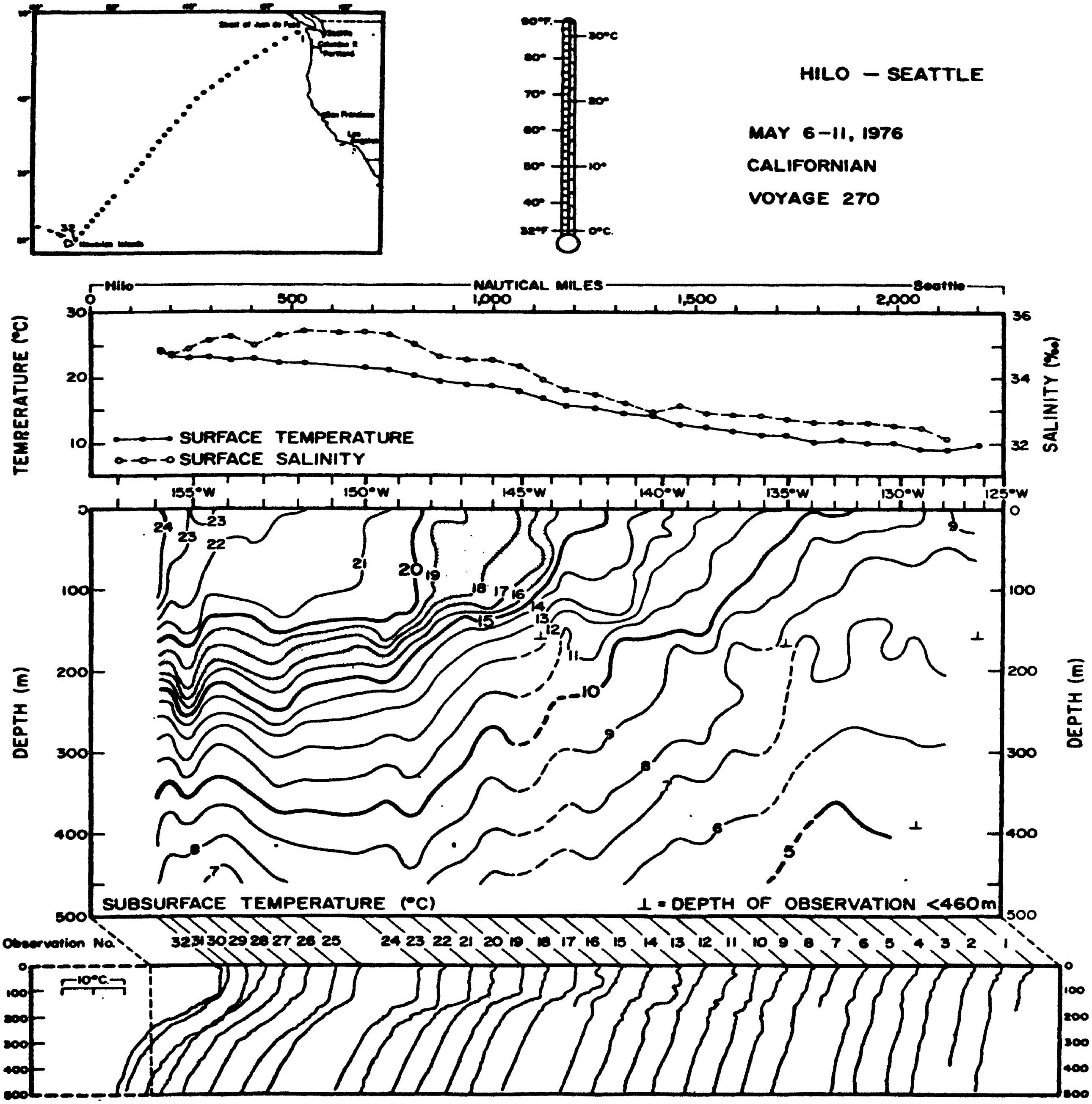


Figure 2a. Surface temperature and salinity and subsurface temperature structure from expendable bathythermograph observations between Seattle and Hawaii.

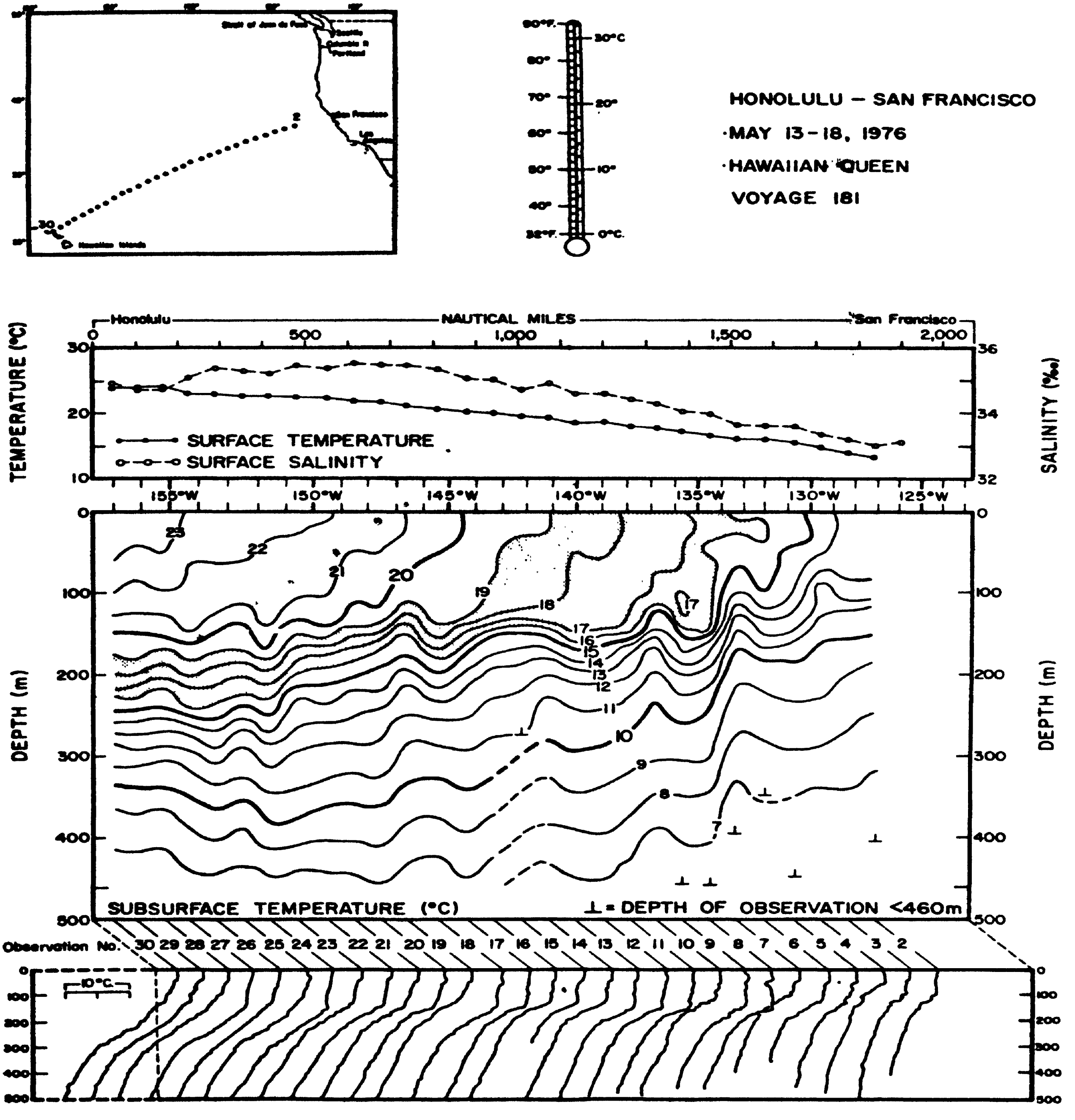


Figure 2b. Surface temperature and salinity and subsurface temperature structure from expendable bathythermograph observations between San Francisco and Hawaii.

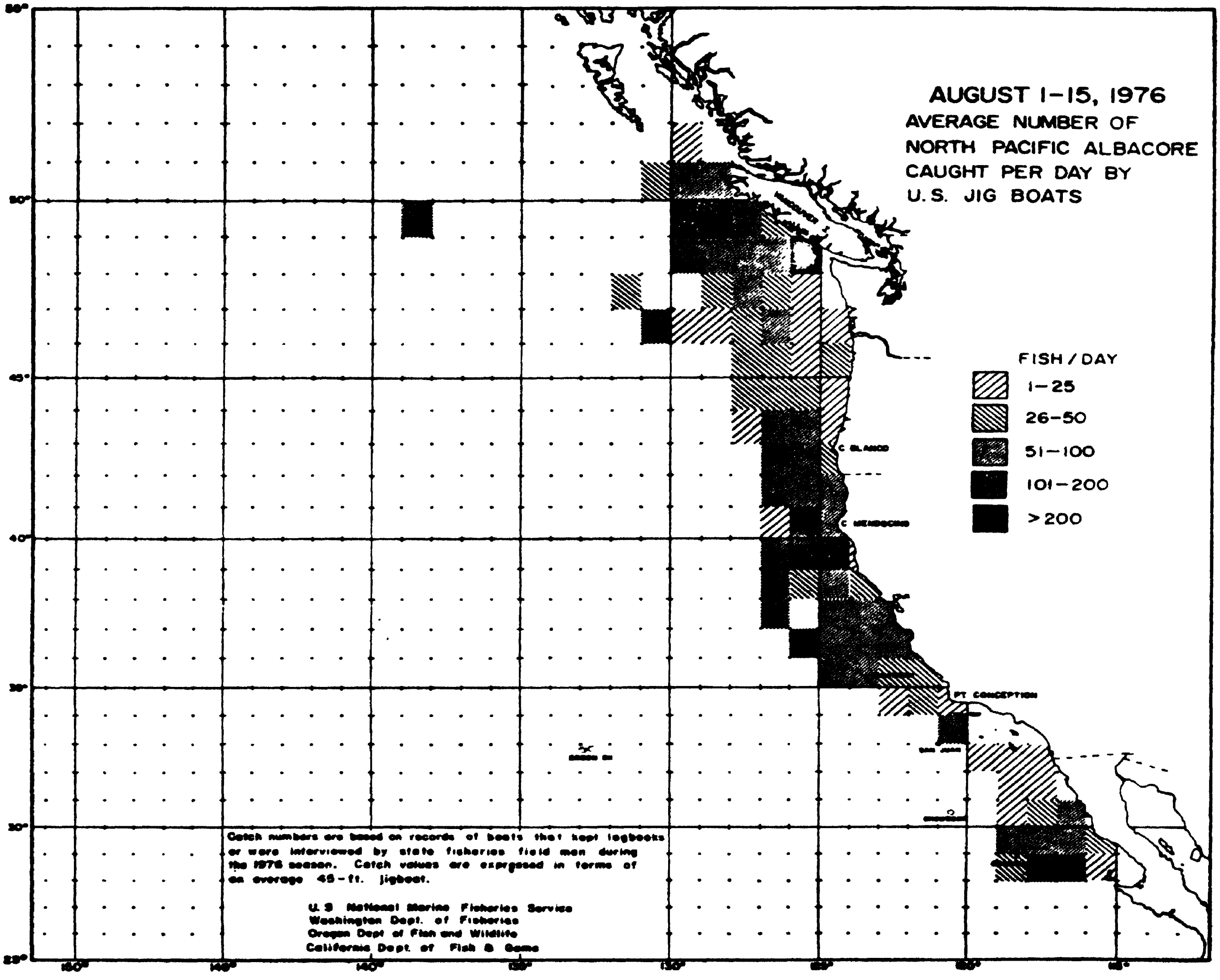

AUGUST 1-15, 1976
AVERAGE NUMBER OF
NORTH PACIFIC ALBACORE
CAUGHT PER DAY BY
U.S. JIG BOATS
FISH / DAY
▨ 1-25
▨ 26-50
▩ 51-100
■ 101-200
■ >200
C. BLANCO
C. MENDOCINO
PT. CONCEPTION
Catch numbers are based on records of boats that kept logbooks or were interviewed by state fisheries field men during the 1976 season. Catch values are expressed in terms of an average 45-ft. jigboat.
U.S. National Marine Fisheries Service
Washington Dept. of Fisheries
Oregon Dept of Fish and Wildlife
California Dept. of Fish & Game
55°
50°
45°
40°
35°
30°
25°
150°
145°
140°
135°
130°
125°
120°
115°

Figure 3. Chart distributed to fishermen showing nominal catch per unit effort by 15-day period and 1° quadrangle.

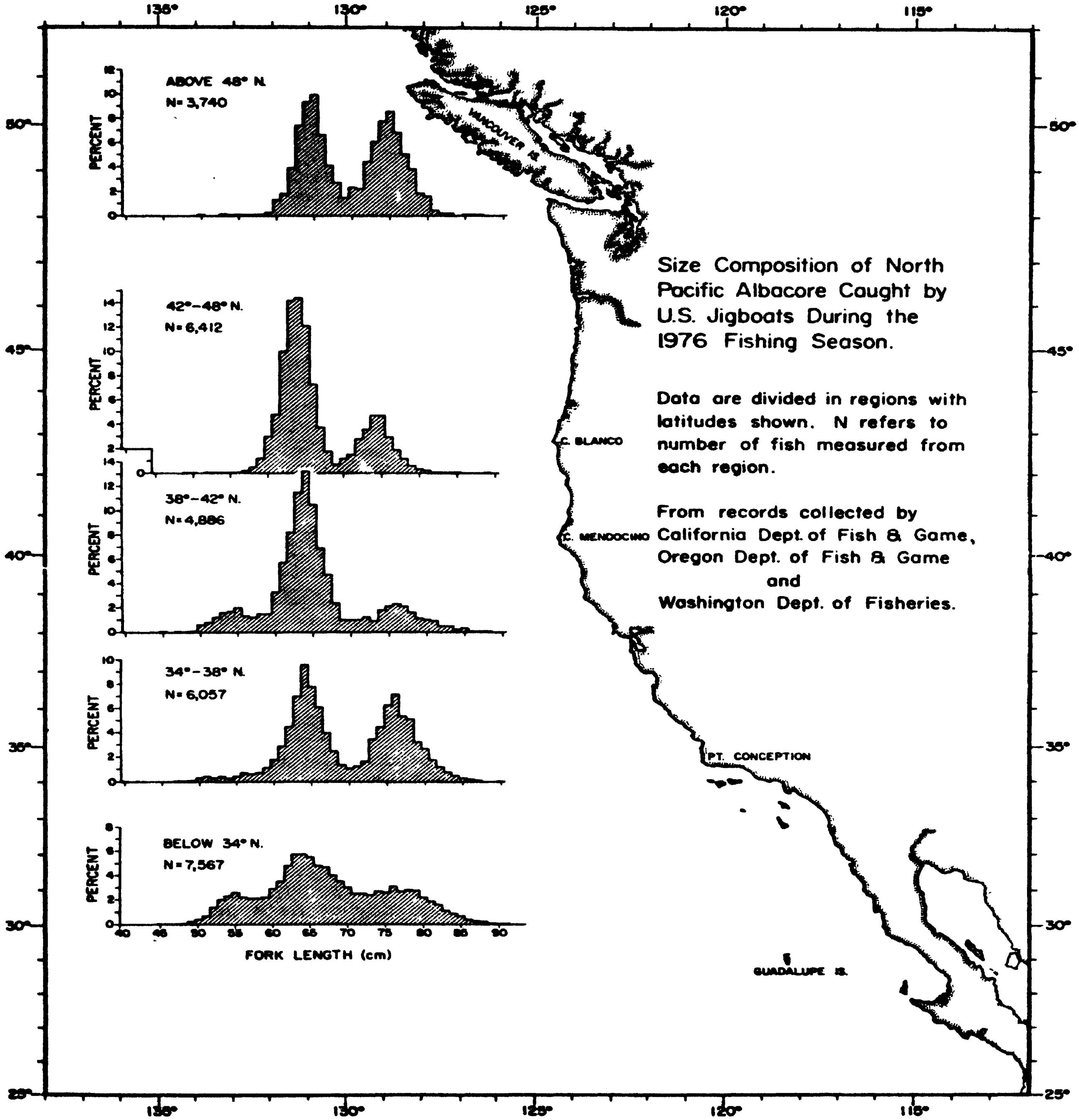


Figure 4. Chart distributed to fishermen showing size composition of albacore caught in commercial fishing.

9. SEA SURFACE TEMPERATURE FRONTAL CHARTS TO ASSIST PACIFIC SALMON AND ALBACORE FISHERIES

by

F. Jurick

9.1 Introduction

An experimental programme for delivering temperature information was initiated in 1975 to aid Pacific salmon and albacore fishermen in locating commercial quantities of fish. Sea surface temperature charts are produced and distributed by the National Environmental Satellite Service (NESS) Field Station in Redwood City, CA. The charting format was developed cooperatively by the Satellite Service and the Humboldt State University Sea Grant Marine Advisory Program. Success of the programme has been measured by the very high degree of interest and feedback from the fishing industry. A similar chart is now being cooperatively produced by the U.S. Weather Service, Ocean Services Unit, in Seattle, WA, to cover the waters from Oregon to Vancouver Island, British Columbia.

9.2 Scientific background

Pacific salmon and albacore tuna are caught in commercial quantities off the West coast of the United States. Both fish exhibit temperature sensitive traits. The species of salmon involved are coho (Oncorhynchus kisutch) and probably chinook (Oncorhynchus tshawytscha). Coho salmon seem to prefer temperatures ranging from 11.1 - 13.3° C. Albacore (Thunnus alalunga) is a temperate species of tuna and is known to congregate near thermal boundaries which form along the coast, often associated with coastal upwelling. Fortunately, salmon and albacore are fished commercially during the upwelling season when sea surface temperature gradients are maximum, allowing many of these ocean thermal boundaries to show well on satellite imagery. This period extends from late spring through mid fall.

The relationship between coastal upwelling and fish production is well-known. Upwelling brings to the surface nutrients upon which plankton, bait fish, and ultimately predator fish such as salmon and albacore feed. The importance of temperature gradients is not new to fishermen, who expend much time and energy locating favourable water conditions. Experience has shown that locating thermal boundaries rather than absolute surface temperatures is more mportant in finding favourable fishing ground. Therefore, the purpose of the charts is to id fishermen in locating these frontal boundaries in as real-time as possible. The direct dvantage to fishermen is a saving in time and fuel. Frequency of data depends on the coastal loud cover, which at times can be a problem, but during the 1976 fishing season, the programme veraged one to two charts per week.

9.3 Environmental product preparation

The basic data for the charts is derived from enhanced VHRR (Very High Resolution Radiometer) infra-red imagery provided by the National Oceanic and Atmospheric Administration (NOAA) satellites, particularly NOAA-5, the latest in the series. The VHRR is sensitive to he infra-red (IR) window between 10.5 and 12.5 microns and has a spatial resolution of approximately 0.9 km at the subpoint.

A secondary source of data is the NOAA SMS-2 (Synchronous Meteorological Satellite) which provides a greater frequency of coverage (every half hour) but has a much coarser resolution. The satellite does complement the programme well as a constant monitor of cloud cover which blocks any usable surface data. Both satellite systems also provide visual imagery which allows the interpreter to identify cloud-covered areas.

Frequency of the VHRR-IR imagery provided by the NOAA-5 polar-orbiting satellite is twice daily. The raw IR data are enhanced by use of computerized enhancement tables. Data values are reassigned such that selected temperatures are expanded over the entire gray-shade scale from white to black. This process improves contrast and sharpens apparent surface edge gradients (Figures 1 and 2). At this point, the interpreter selects significant frontal features. This stage is quite subjective, but experience and user feedback has improved the quality of selection. Experience also shows that frontal features in certain locations are more important than others. Once frontal boundaries are selected, these features must be located geographically, because unfortunately raw satellite imagery collected from NOAA-5 contains aerial distortion which increases in either direction towards the horizon. To compensate for this type of distortion, a device called the Zoom Transfer Scope (Bausch and Lomb trade name) is used to stretch and project an image onto a base chart. The selected oceanographic features can then be manually transferred to the base chart. In this case, the coastline is used as a reference to determine the amount of stretch needed to compensate for the aerial distortion. Charts are normally produced the same day information is received (Figure 3).

9.4 Distribution of charts - planned further improvement

Once the base chart has been prepared, the information is communicated via radio-facsimile and telephone-facsimile. Radio-facsimile is broadcast from San Francisco, CA (NMC) twice daily. Telephone-facsimile is accomplished by means of a Redwood City, CA, based Xerox Telecopier. This system allows the use of an automated land-based communications system by anyone with a compatible receiver. A taped message precedes the chart transmission to give pertinent highlights and avoid duplication of charts. Industry and government offices along the coast routinely receive copies of the frontal chart and distribute them accordingly in their respective areas.

A planned future improvement is the inclusion of some absolute temperatures on the chart. This will be done either by locating spot readings from ground-truth sources or including selected isotherms. During the fall of 1976 a new chart to cover the Baja California coast was also instituted. The programme also envisages expanding its communications into existing government and commercial weather broadcasts.

9.5 Editor's note - References

The service described by Mr. F. Jurick seems to be the first which succeeded, on a routine basis, in "real-time" translation of satellite data for use by fishermen.

It should be pointed out that another programme aimed at locating coastal coho salmon stocks off the Oregon coast was operated in 1973 as a pilot project (Wright *et al*., 1976). In this case, mapping of sea surface temperature was executed by a research aircraft and rapid dissemination of the forecast was effected by telecopying it to user locations.

The pilot programme was found to be successful in locating 11°-13°C water in 38 out of 41 SST maps issued during a two-month period of the programme. As can be seen from the number of maps issued, SST mapping flights were possible only 58 percent of the time because weather conditions and limited visibility in the coastal upwelling areas were often a seriously limiting factor in using aircraft. Operationally the aircraft is also a limiting factor as regards the area covered by the flights. The pilot programme was restricted to an area of 60-80 miles along the Oregon coast out to about 20 miles offshore.

If a specific fishery is confined to a small inshore area, such as that covered by the above pilot programme, mapping by aircraft may have some advantage as visual sighting will also allow the pilot to locate frontal zones of fish schools. The programme executed by Wright *et al*. (1976, *loc. cit*.) provides a good example as to how such programmes could be organized.

The use of satellite data, on the other hand, allows coverage of a wide area whereby limiting factors, such as cloudiness, can be overcome by the high frequency of satellite pictures as shown above by Jurick. Some papers containing information on the development of the experimental programme on the use of satellites for SST frontal charts are given below.

Breaker, L. and F. Jurick, Providing near real-time sea surface temperatures to
1975 the California north coast fishing fleet: an approach. *In* Ocean 75 (Combined meeting of 1975 IEEE Conference on Engineering in the Ocean Environment and the 11th Annual Meeting of the Marine Technology Society). San Diego, California, September 22-25, 1975. New York, Institute of Electrical and Electronics Engineers, Inc., pp. 794-7

Gorman, B.E., Fishing by satellite - Those big ones won't get away any more.
1976 *NOAA*, 6(1):29-31

Jurick, F., Space age technology makes job easier for West Coast fishermen. *Sea Grant*,
1977 7(6):3-5

Klopfenstein, D. and I. Klopfenstein, Satellite photos may help fishermen. *The*
1976 *Fishermen's News*, 1(2):3 p.

Wright, D.J., B.M. Woodsworth and J.J. O'Brien, A system for monitoring the location
1976 of harvestable coho salmon stocks. *Mar.Fish.Rev.*, NMFS/NOAA, 38(3):1-7

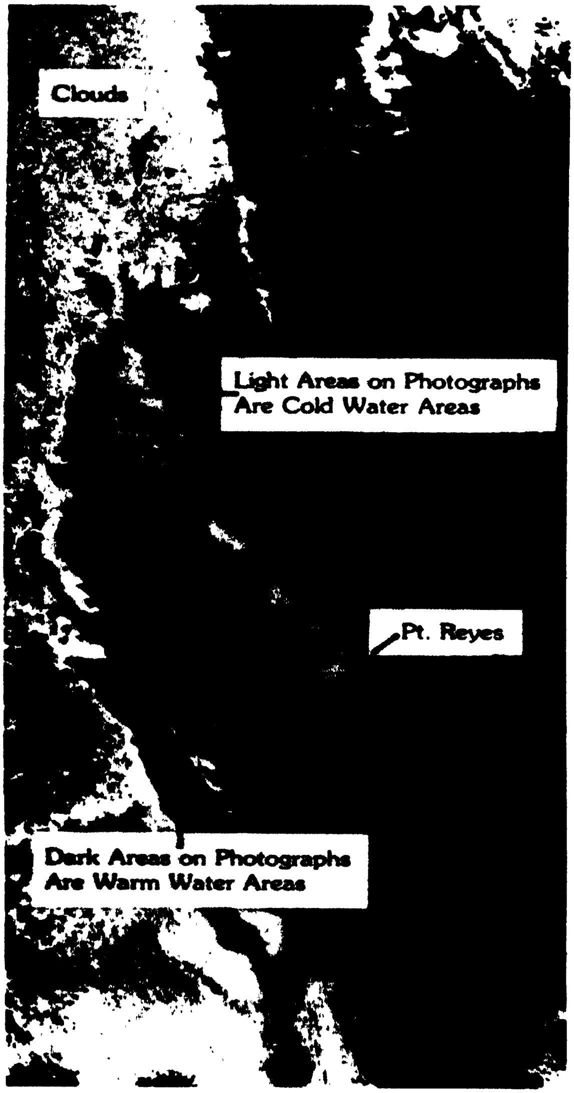

Clouds
Light Areas on Photographs Are Cold Water Areas
Pt. Reyes
Dark Areas on Photographs Are Warm Water Areas

Figure 1: This is a NOAA-3 satellite infra-red photo. White areas show cold upwelled water. Dark areas are warm water

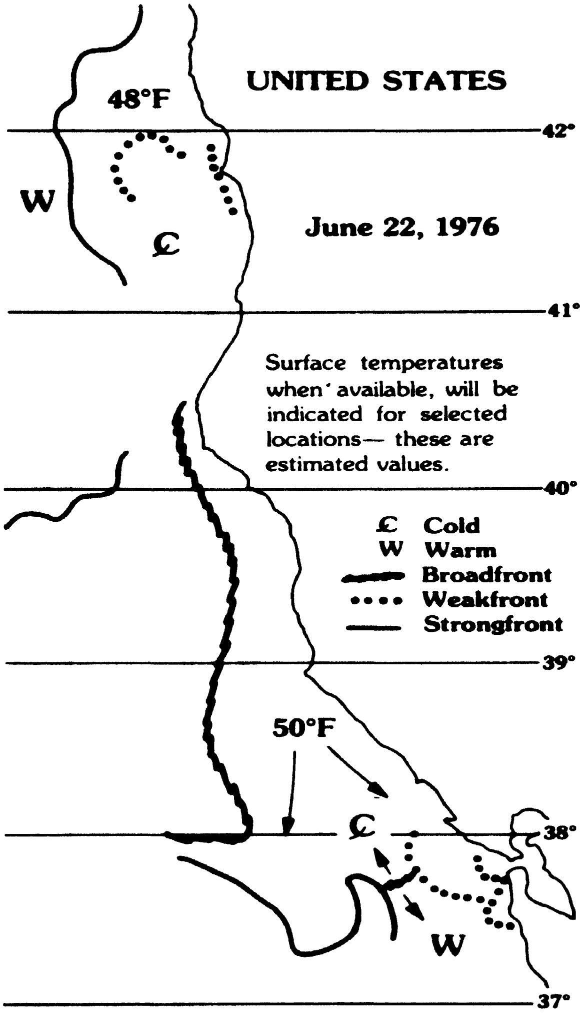

UNITED STATES
48°F
W
C
June 22, 1976
42°
41°
Surface temperatures when available, will be indicated for selected locations— these are estimated values.
40°
C Cold
W Warm
Broadfront
Weakfront
Strongfront
39°
50°F
C
38°
W
37°

Figure 2: Chart made from satellite photo. Temperature fronts are drawn in

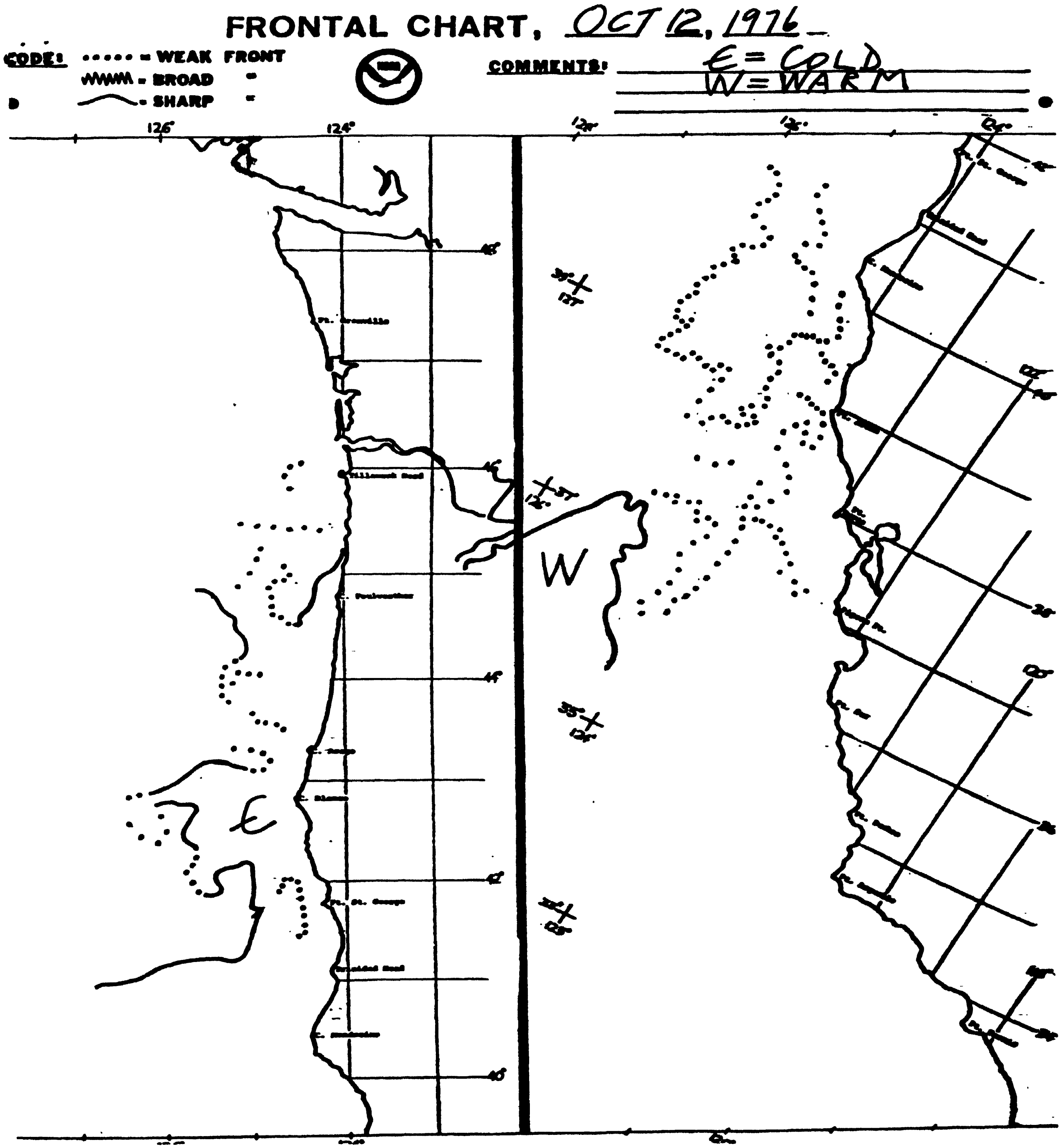


Figure 3: Example of a frontal chart distribution to fishermen; 12 October 1976

10. U.S.S.R. MARINE METEOROLOGICAL FISHERY SERVICES

by

K.P. Vasiliev

10.1 Introduction

To run a modern fishing industry requires a continuous supply of practical, reliable and complete information as a basis for optimal decision-making. No small factor in this management work is marine meteorological information which is virtually a sine qua non for carrying out any of the functions of a fishing industry.

The work of a fishing and transporting fleet, modern fish searching and catching methods, and the operations of ports and fishing industry enterprises ashore are directly dependent, and often decisively so, on environmental conditions.

Marine meteorology for fishing operations is a specialised service, focusing on the influence of meteorological and oceanographic conditions on production plant and equipment and on the operations of a fishing industry in seas, oceans and the marine estuaries of rivers.

The marine meteorological servicing of the production activities of fishing organisations is carried out both from shore weather stations and by forecasting teams specially organized to service fishing vessels on the fishing grounds themselves.

It is very important for fishermen to know not only the meteorological and oceanographic conditions which affect the safety of their vessels, but also the factors that directly influence their catch. While to ensure its safety the fishing vessel has to be warned in good time of oncoming storms, the possibility of icing aboard, loss of visibility and the presence of ice in the sea; the fishing fleet also needs timely information on water temperatures, wind directions, cloud cover, wind waves and swells, the phases of the moon, etc.

Specialized marine meteorological services differ from one oceanic area to another, with the geographical location of the fishing ground, the type of vessel working it and the fishing gear used, among other factors. Some examples of such services to a fishery are given below. It should be pointed out however that, in addition to those referred to, there are other marine meteorological phenomena that affect fishing operations and shore installations, and oceanographic services should make a constant study of the influence of meteorological and oceanographic conditions on fish behaviour, fishing gear, fishing vessels, and shore facilities.

10.2 Forecasts of sea ice

In winter, sea ice greatly hampers fishing operations. As it spreads, it blankets over rich fishing waters, for example, those of the Labrador shelf, and off St. Matthew and Pribilof Islands. Fishermen need to know whether ice conditions in these waters are expected to be easy or difficult so as to decide whether it is worthwhile sending a fishing fleet there.

The success of a fishing operation off Labrador depends chiefly on a correct assessment of ice conditions and wind directions. At the beginning of the ice season winds out of the northern quarter follow the prevalent direction of the Labrador current, building up a heavy drift of ice out of Baffin Bay, which gradually closes off the fishing grounds of central and southern Labrador and the Grand Banks off Newfoundland. During the period when the area of floating ice is at its widest extent, when the ice edge stretches out beyond the continental shelf, northerly winds push the drift ice further, causing the formation of extensive patches of open water in which a fleet can trawl successfully. In such situations information on prevailing winds and the expected direction of ice drift is of crucial importance to the fisherman. Indeed, information on the actual ice situation on the fishing ground together with the coordinates for the ice edge and the dimensions and orientation of trawlable open water patches assure the success of a fishing operation. Recommendations on the best and safest course out of a floe area into the open sea or into a patch of open water within a floe area, and consultations on possible changes in the ice conditions, enhance the safety and effectiveness of fishing fleet operations.

To fish successfully on the Labrador shelf it is necessary to know the expected ice situation in advance (up to a month ahead). If it is concluded that the area can be fished, it is still necessary to provide information on ice conditions and a forecast of expected changes in them during the next 24-48 hours, and on winds during the next 12, 24 and 48 hours. Weather forecasts and consultations on ice conditions save time for fishermen in moving from one sea area to another and searching for new fishing grounds, and enhance the safety of navigation.

10.3 Forecasts of storms and changes in wind directions

In the coastal waters of the Barents and Norwegian Seas the critical factor in successful fishing is timely storm and all-clear warnings to fishermen. The offshore waters are fished by small purse-seines, some of which, when full, take 4 to 6 hours to haul in. Operations are hindered by storm winds, which are fairly frequent in these seas. Winds of force 6 and above are dangerous for shallow-craft purse-seiners. Hence the marine meteorologist must be particularly attentive and responsive to the needs of these craft. To ensure the success of fishing vessel operations half-day, day and periodical (4 to 6-day) weather forecasts are compiled for each fishing ground. It is very important to make timely adjustments in these forecasts for the next 4 to 8 hours. Information on the expected weather conditions has to be so detailed because of the need to exploit all "gaps" of favourable fishing weather in the general picture of stormy weather.

Forecasts of expected storm duration are also of considerable significance in marine meteorological services to purse seiners. Fishing vessels may leave the open seas and take refuge in bays and gulfs where they go on fishing the smaller capelin stocks. Skilled fishermen can use the expected weather to redeploy their fishing ships and the refrigerated carriers in such a way as to reduce unproductive costs considerably.

Capelin and polar cod are fished in the inshore waters of Kolguyev Island every autumn and winter. These waters are noted for their severe weather conditions and a particularly painstaking service is indispensable. Polar cod are caught with trawls, which is dangerous in winds of force 8 and above. Fishing is rendered arduous by violent storms, early ice, and heavy icing up of vessels.

Hence forecasts of changes in wind bearing are very important for craft working off Kolguyev Island. Warned in good time of changes in wind direction that hamper fishing operations, mother ships and refrigerated carriers can leave their stations and move over to the lee side of the island.

10.4 Sea surface temperature forecasts

The surface water temperature is important for its regime is closely connected with the concentration density of the fish and their approach to the fishing ground. The anchovy of the Sea of Azov, for example, congregate in dense schools and approach the Kerch peninsula when the temperature of the water reaches 12°C.

To fish for saury in the northwestern Pacific Ocean a forecast of water temperature, or rather data on temperatures above 15°C is needed. There is a dense concentration of saury at the convergence zone between warm and cold waters at temperatures of 14-18°C, and such oceanographic conditions are recorded at the junction of the cold Oyashio and the warm Kuroshio waters. Here conditions are favourable for the rapid multiplication of plankton and the approach of the saury schools. Saury are caught at night, under light. This method is most successful on moonless or cloudy nights. On moonlight nights saury are less responsive' to light. One distinctive feature of a marine meteorological service to saury fishing is the strong influence of the phases of the moon and cloudiness, and also the choppiness of the sea, for in heavy seas and wind-driven waves (3 m and higher) lamps hung out over the side are swamped, which puts them out of commission and causes the breaking of trapnet frames (the fishing gear).

Thus, successful saury fishing calls for a long-range (one-month) forecast of water temperatures, a forecast of cloudiness (3-5 days) and of the phases of the moon, and a forecast of wave force (24 hours).

10.5 Forecasts for whaling operations

Whaling is dependent to a considerable extent on marine meteorological conditions. The principal oceanographic dangers for whaling boats, making operations impossible, are:

(i) winds of force 8 and above

(ii) lack of visibility, particularly among icebergs and floes

(iii) waves more than 3.5 m high

(iv) ice formation on the ship

Whales can be searched for and hunted down when the visibility is good and the wind and seas are moderate. In high winds, starting from force 7, wave crests topple, forming swirling spume - the so-called "barashki" or whitecaps, which hinder the detection of whale spouts.

It is also very important to predict even minimal icing. For example, when the antennas of radio buoys in the carcasses of caught whales are coated with ice the radio buoys become inoperative, which can cause the loss of the whale catch. In seas with waves higher than 3.5 m cables can part and towed whales can be lost.

Thus to ensure normal whaling operations it is essential to compile forecasts for wind, visibility, wave motion, icing, and provide information on ice conditions (the location of the ice edge and the presence of icebergs). Forecasts for the weather should be made from 6 hours to 72 hours ahead, and for seas, icing and visibility from 12 to 24 hours ahead.

Examples of sea surface temperature maps, based on heat budget calculations utilizing long-range meteorological forecasts, which are provided to the fishing industry in advance by the U.S.S.R. Marine Meteorological Service are given in figures 1a-d and 2a-b.

Figure 1: Long-term forecasts of sea surface temperature in the Sea of Asov showing the calculated temperature distribution for November/December 1976. issued by the U.S.S.R. Marine Meteorological Service

a) Forecast for 1 November 1976
b) Forecast for 15 November 1976
c) Forecast for 1 December 1976
d) Forecast for 15 December 1976

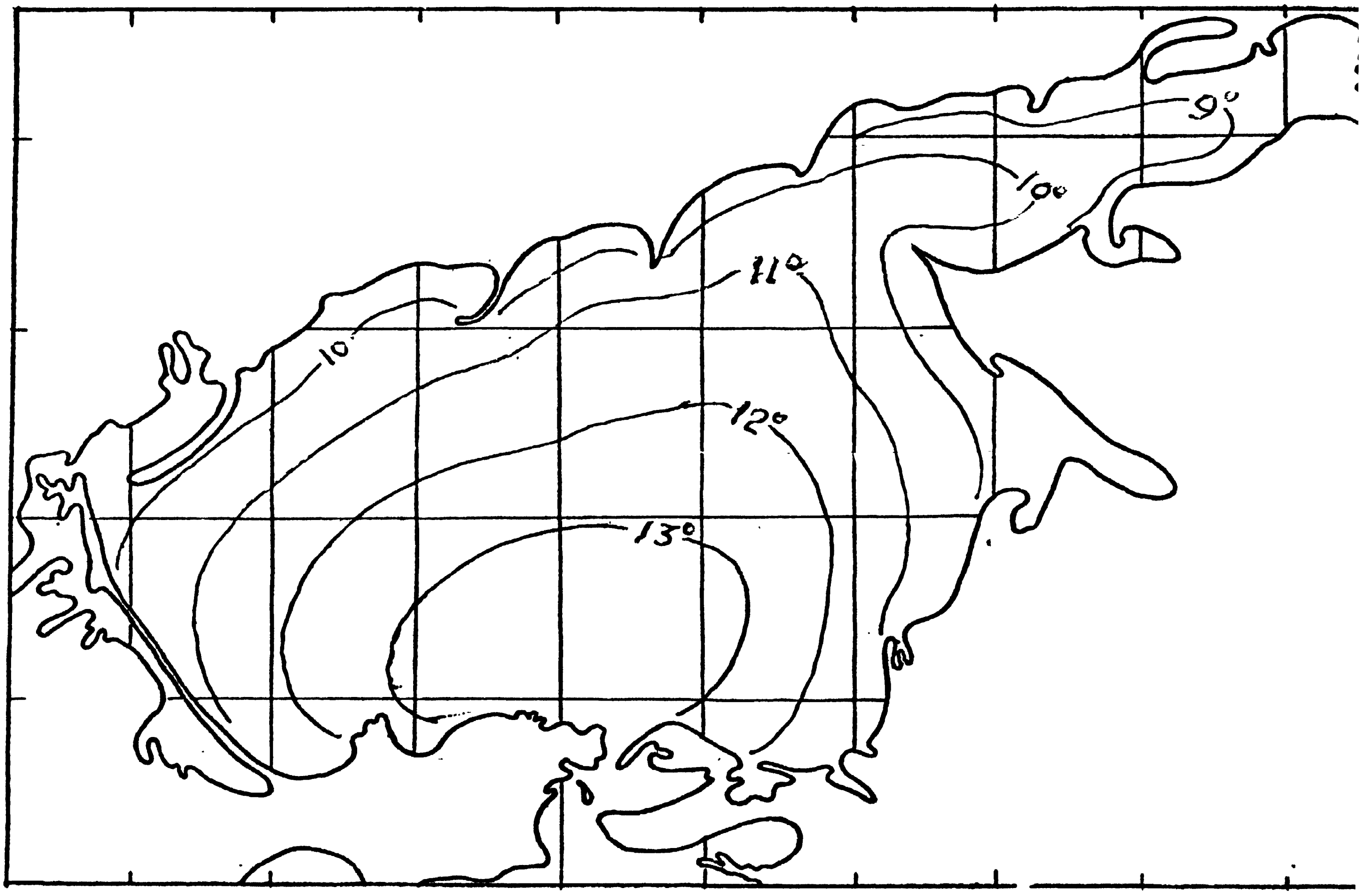


Figure 1a

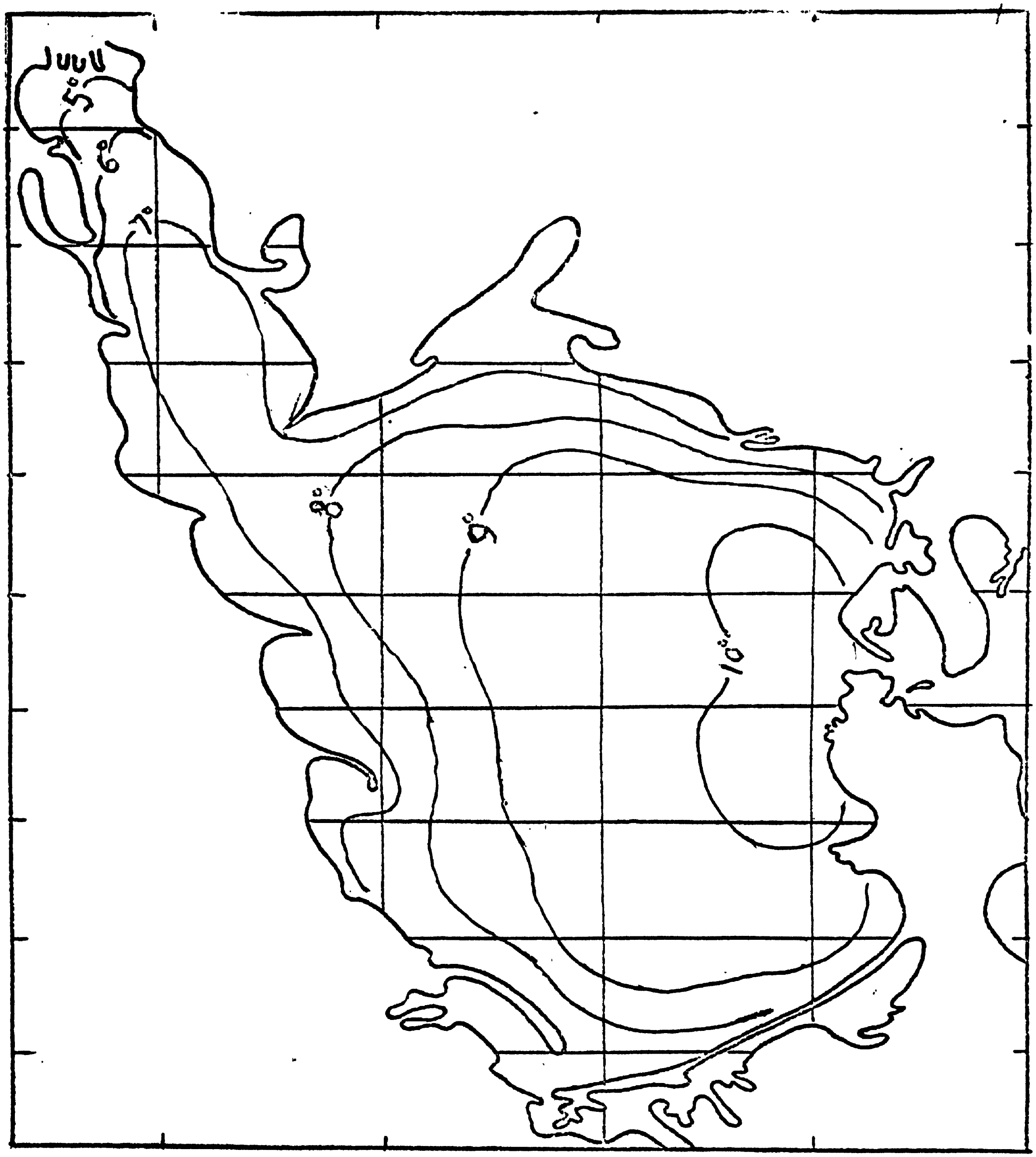


Figure 1b

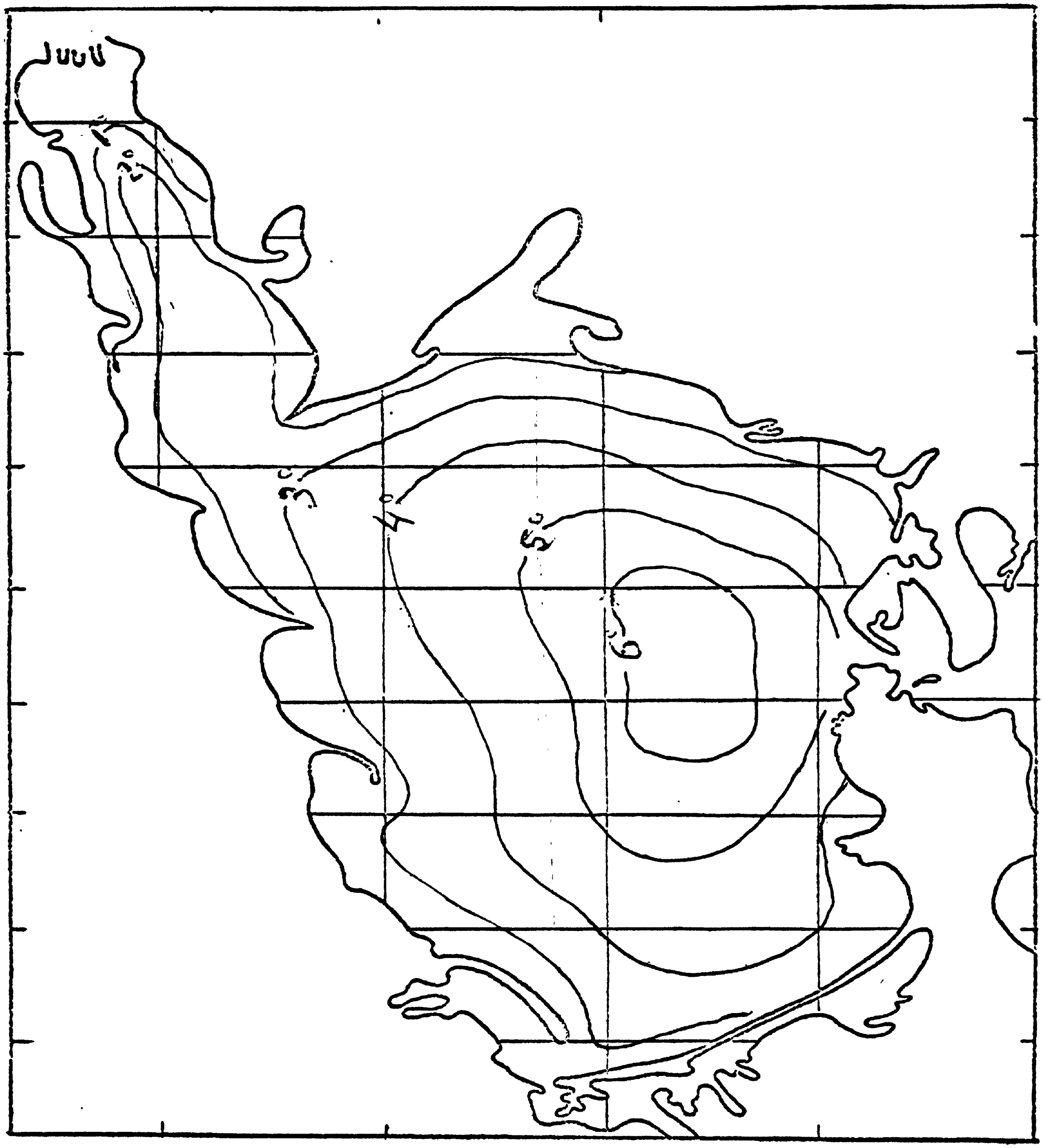


Figure 1c

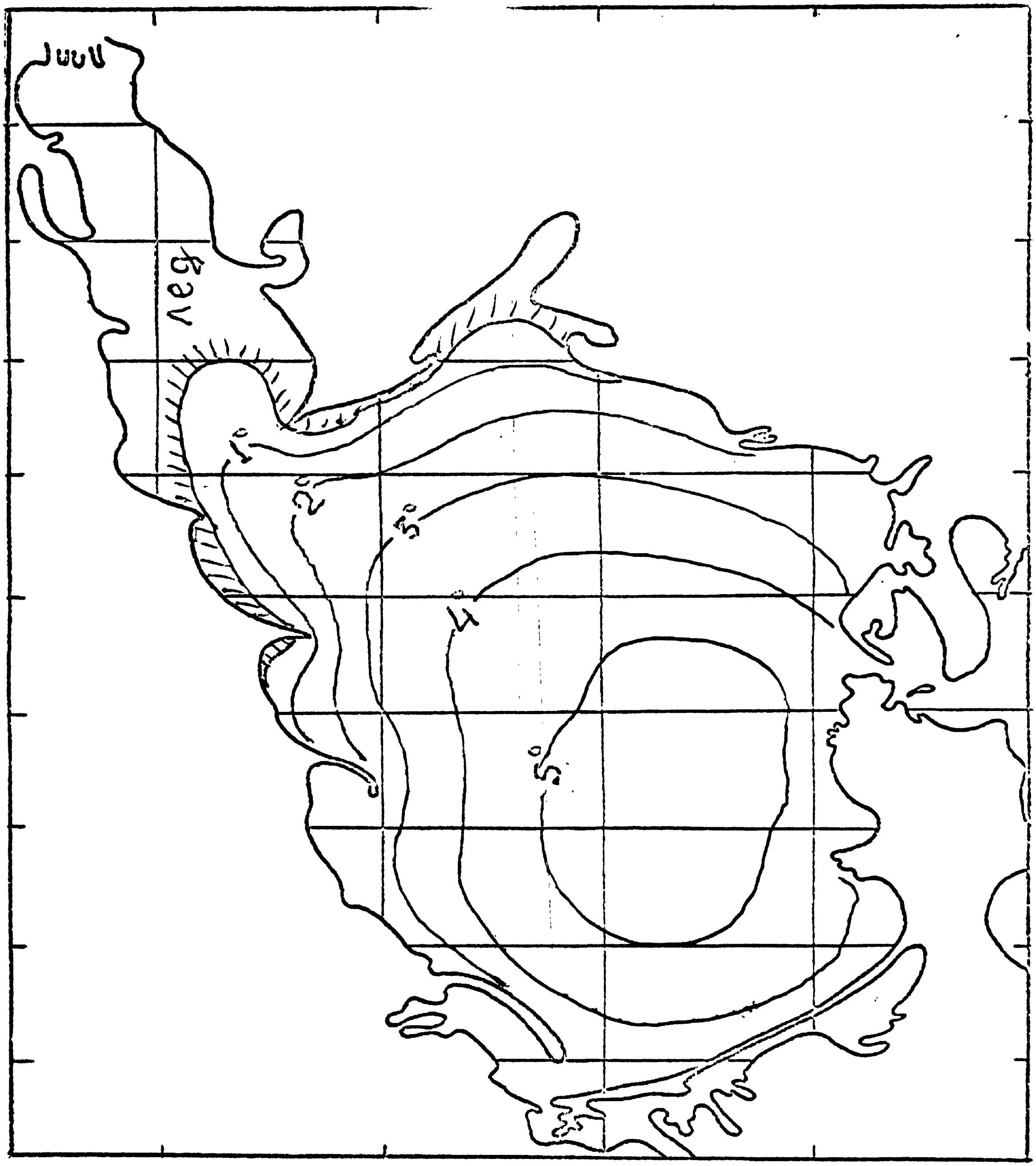


Figure 1d

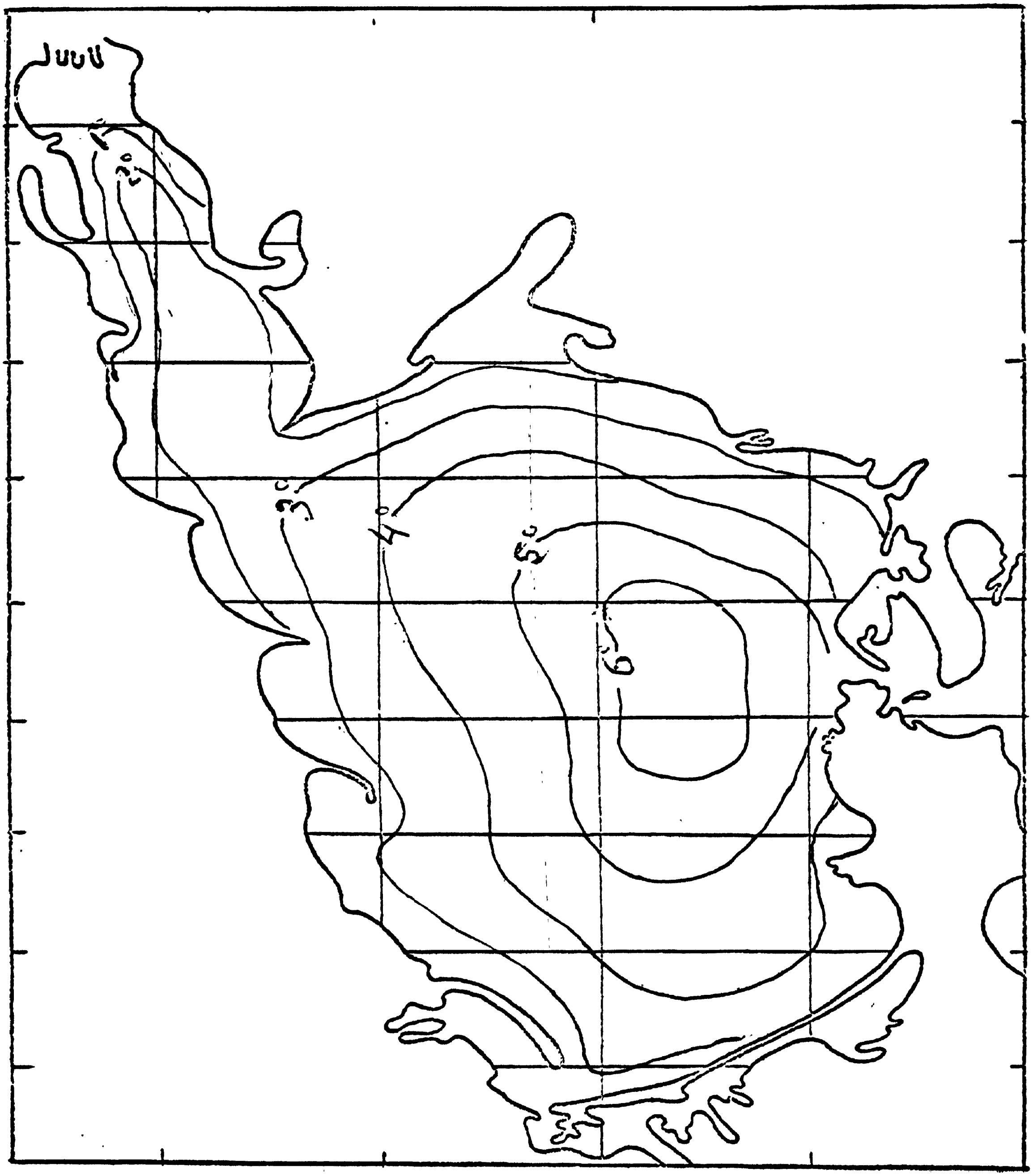


Figure 1c

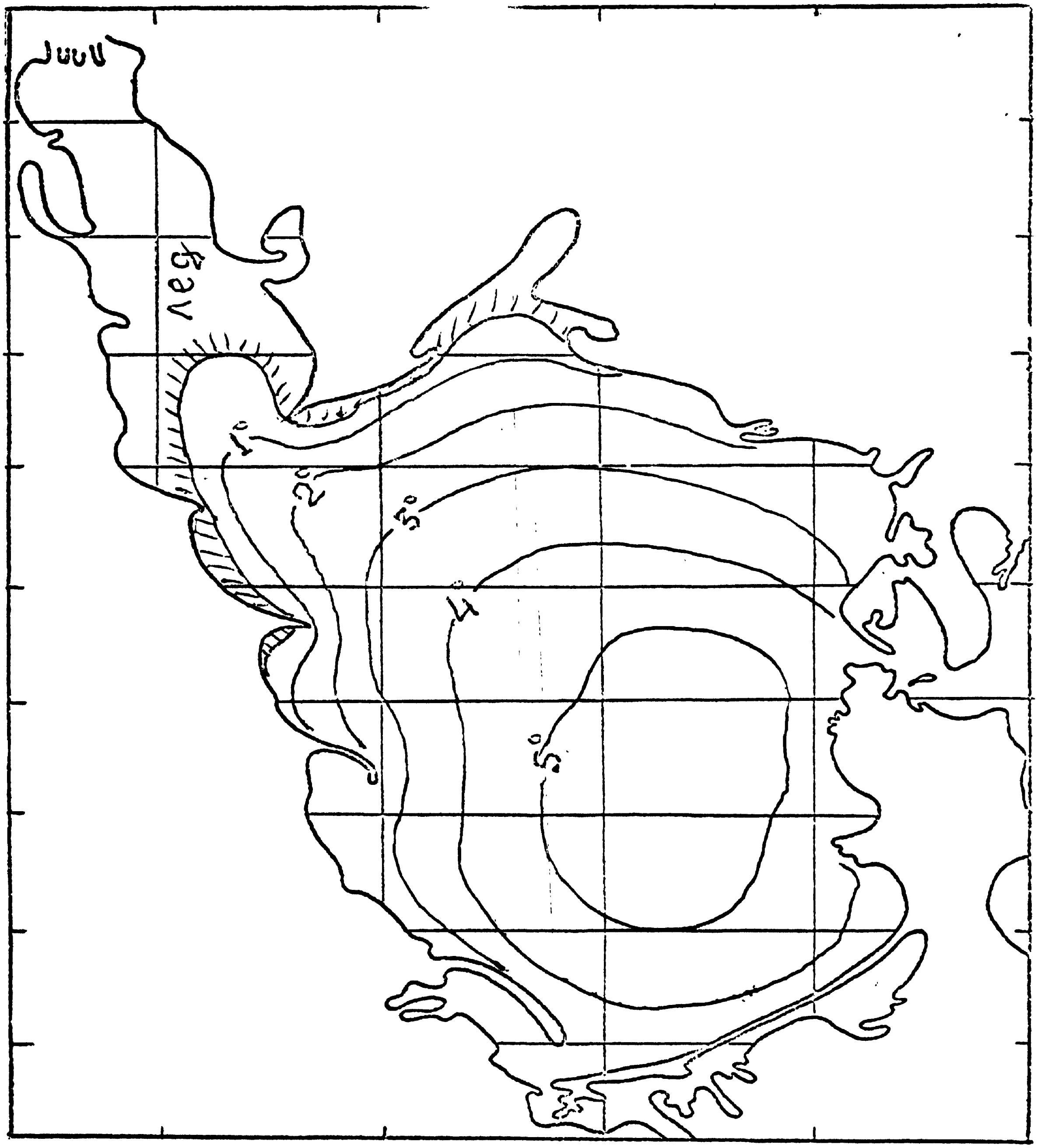


Figure 1d

Figure 2: Long-term forecasts of sea surface temperature in the North Atlantic Ocean including the calculated location of the pack-ice sheet in the northern part, issued by the U.S.S.R. Marine Meteorological Service.

a) Forecast for 11-15 January 1977
b) Forecast for 11-15 March 1977

(publication suspended until autumn 1977)

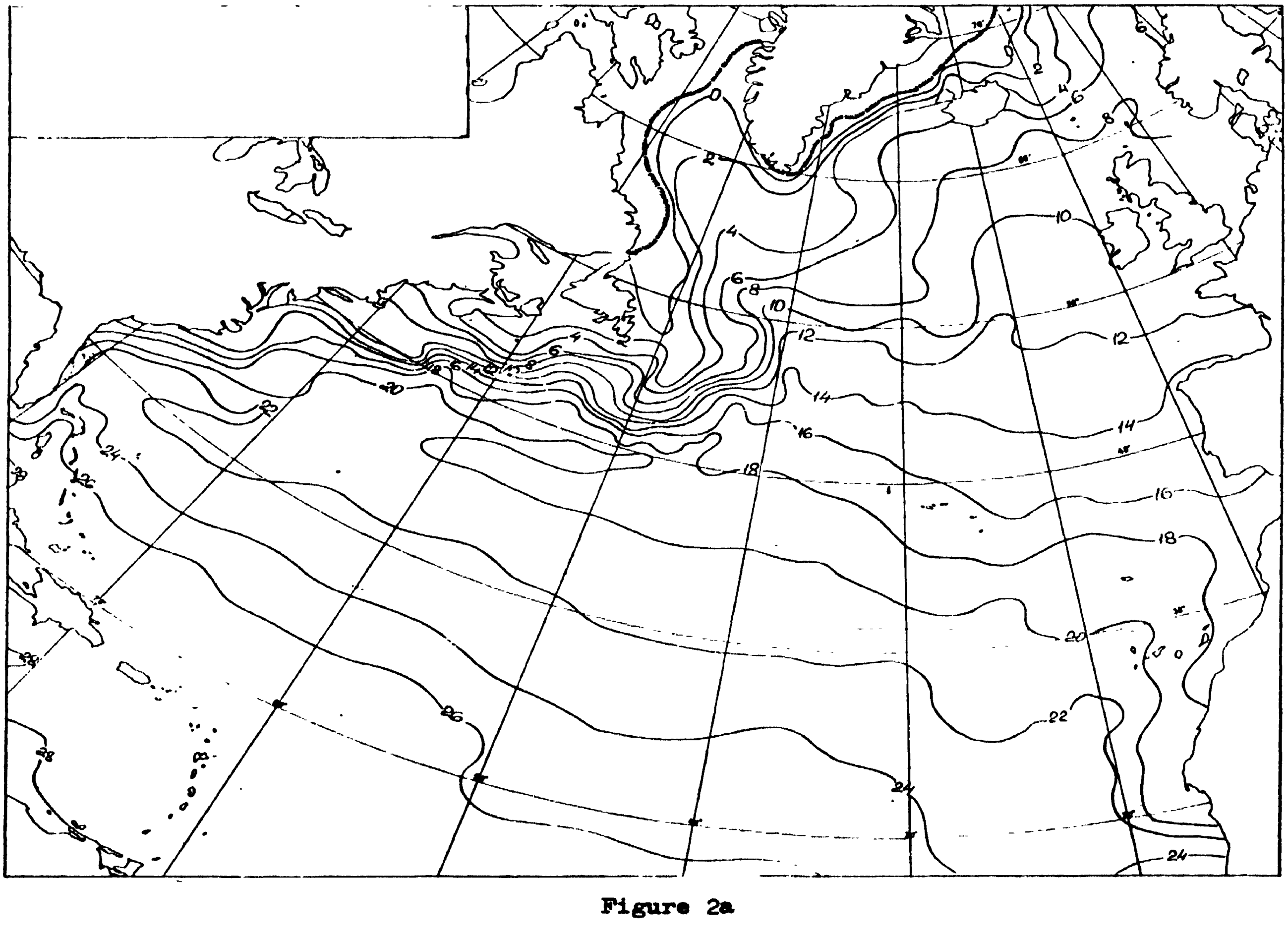


Figure 2a

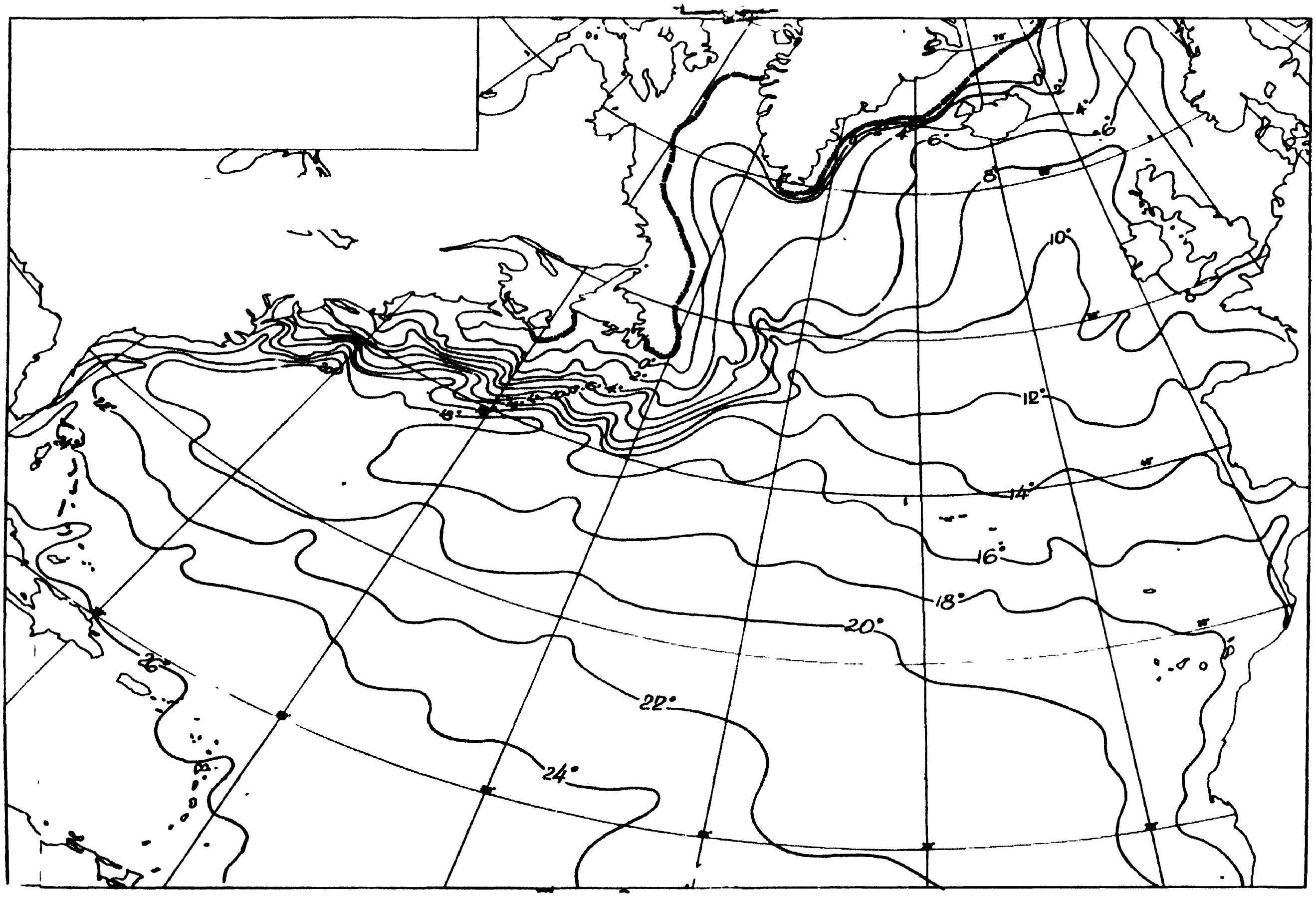


Figure 2b

11. OTHER EXISTING OR PROPOSED ENVIRONMENTAL SERVICES

by

G.H. Tomczak

PREFACE

This section gives information about environmental services or related proposals based on descriptions found in the literature. For various reasons authors of these papers were unable to provide a picture of expected further development of these services, or suggestions. However, in order to complete this review on fisheries environmental services, a short summary of the related literature is given.

11.1 Icelandic herring search and information service[1]

11.1.1 Introduction

The system was developed about the early 1940s and proved to be successful particularly during the late 1950s and early 1960s just before the herring fishery collapsed due to drastic reduction of the Atlanto-Skandian herring stocks. It is now being used successfully to monitor migrations of capelin and to some extent, of blue whiting (Jakobsson, personal communication).

The system consists of a pre-seasonal information system on herring distribution and environmental conditions and seasonal herring sonar surveys executed by a few specialized ships and personnel.

11.1.2 Background

Although aerial scouting based on the private initiative of some Icelandic pilots started as early as 1928, it became a well developed method of locating herring schools only in the late 1930s when information on visual sightings was circulated first via the usual radio shore stations and eventually through three specially installed herring information radio stations on the north, northeast and east coasts of Iceland. These stations undertook to direct the aircraft, to rebroadcast all available information to the fishing fleet and, particularly, to provide up-to-date information on landing facilities in the various fishing harbours. Since about 1960 these stations have also served in gathering material on the size and location of catches for statistical use.

About the late 1950s aerial surveys became less important because of the introduction of sonar by which method it became possible to locate herring schools before they surfaced, and because of the fact that the concentration of herring became gradually more and more oceanic and surfacing schools less frequent in coastal areas.

The activities of the herring search and information service therefore switched over from the visual sighting of schools during the actual fishing season to pre-seasonal investigations on the feeding migrations of the stocks in order to locate and trace their movements, and to seasonal herring sonar surveys based on the results of these pre-seasonal investigations.

[1] For more detailed description: see Jakobsson (1971)

11.1.3 Pre-seasonal investigations

These were organized, based on tagging experiments in the late 1940s, to facilitate a better understanding of the migrational patterns (see also part I, section 2.3). Extensive hydrographical and phyto-/zooplankton surveys were carried out annually in May and June, especially in the mixing areas of the cold East Icelandic Current and the warmer Atlantic water. From 1952 this was done as a joint undertaking of research ships from interested ICES member countries which resulted in "joint reports on pre-seasonal herring distribution and environmental conditions". A great number of environmental data has since been collected in the area on a series of hydrographic and plankton collection sections. Figure 1, as an example, shows that by such simultaneous action of the participating research vessels a very good general picture of herring distribution and related environmental factors is received. A second survey of this kind executed a few weeks later will then provide information on the development of the actual herring migration as related to the environmental conditions.

Environmental studies are thus always an important part of the pre-seasonal surveys. It has been demonstrated that both a viable temperature regime and good feeding conditions in the late spring and early summer have similar importance for the distribution of herring.

11.1.4 Seasonal herring sonar surveys

Sea temperature and feeding conditions, especially the availability of the most important food species for herring, the Calanus finmarchicus, as observed in the pre-seasonal studies play an important role in the tactical planning of the sonar surveys of the Icelandic search and information system.

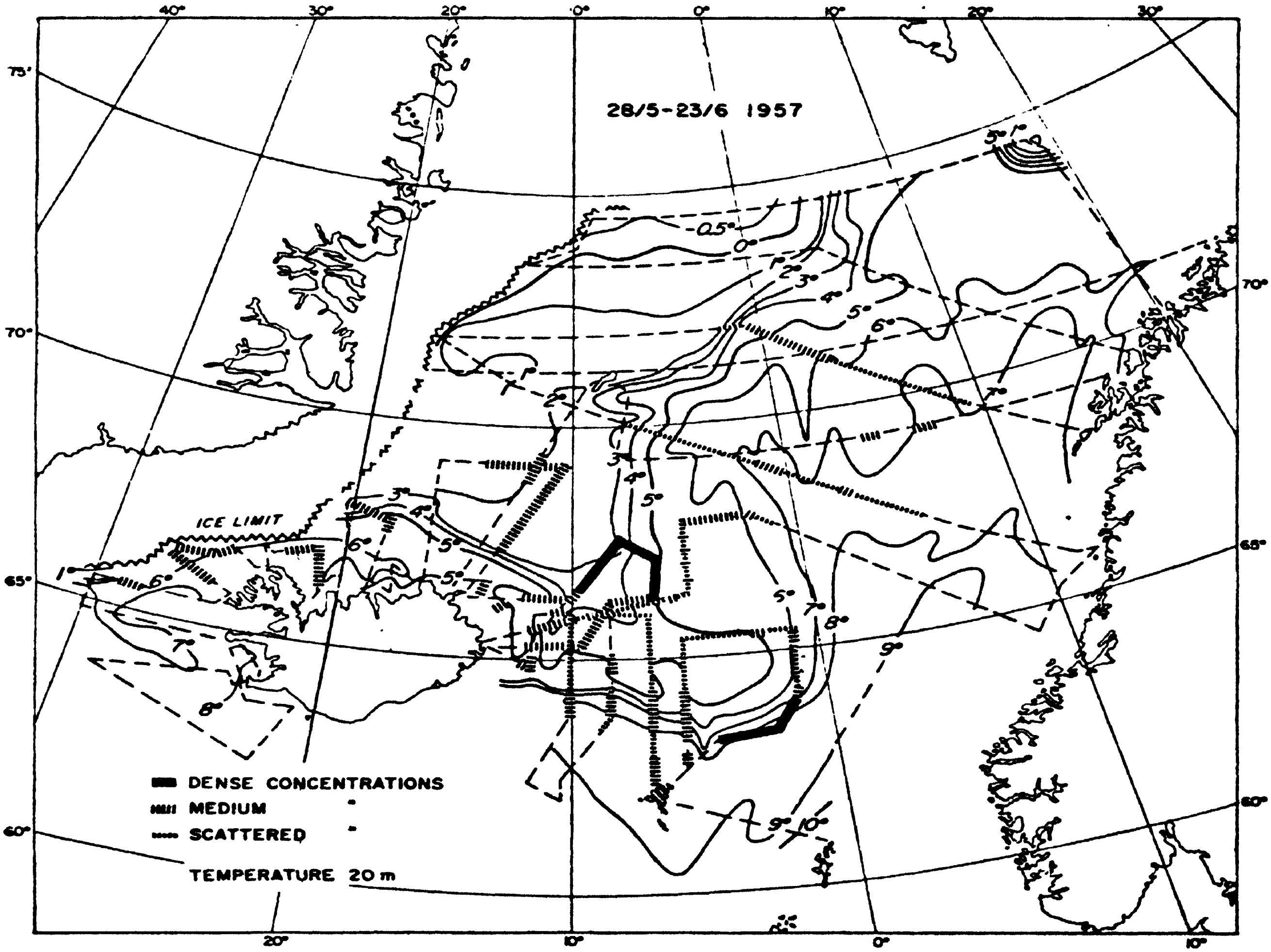
The surveys are executed by one research and two scouting vessels. The research vessel is equipped with a laboratory and facilities for hydrographical and plankton surveys. The scouting vessels commanded by experienced fishing captains are equipped - as is also the research vessel - with long range sonar. The scientist in charge of the research vessel is responsible for the overall planning of the areas surveyed by the three search ships. His ability to explain, in terms easily understandable by the fishermen, the results of the search and the reasons for his short and long-term forecasts, i.e. weeks to months, of the herring migration is of great importance to gain the trust, understanding and support of the fishing captains.

11.1.5 Kind of information provided by the system - System effectiveness

Based on the results of the pre-seasonal studies and following contact with herring concentrations during the seasonal sonar surveys, the following information is broadcast to the fishing fleet:

(i) Position and extent of herring concentrations
(ii) Average size of the schools
iii) Stability of the schooling
iv) Depth and general movement of the schools
v) Approximate number of fishable schools
vi) State of environmental factors that are likely to influence the movements and behaviour of the herring concentrations

Considering the information given particularly during the 1960s when the system was fully developed, it is stated that on a number of occasions information and forecasts were broadcast which resulted in good catches. Further, the search and information service contributed considerably to the successful extension of the north and east coast summer fishery beyond mid-September to the end of the year, and it can also be noted that the Icelandic herring industry, boat owners and fishermen showed a growing interest in the service which eventually lead to an offer to finance the building of a new research vessel, the "Arni Fridriksson". An attempt, however, to assess the actual increase in catch that can be attributed to the seasonal surveys has not yet been made.



(From: Jakobsson, 1971)

Figure 1: The Joint Norwegian, Icelandic and Soviet Union pre-seasonal surveys in 1957

11.1.6 References

Devold, F., 1969 Report of the joint Icelandic-Norwegian-Soviet investigations on adult Atlanto-Scandian herring in summer 1969. Fiskets Gang, 36:602-4

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Østvedt, O.J., The migration of Norwegian herring to Icelandic waters and the environmental conditions in May-June, 1961-1964. Fiskeridir.Skr. (Havunders.), 13(8):29-47

11.2 Analyses and forecasts for North Sea sea surface temperature (SST) and bottom water temperature (BWT)

11.2.1 Introduction

Since 1968 SST charts for the North Sea have been issued weekly by the German Hydrographic Institute (Hamburg, FRG). The maps also contain short verbal descriptions of the temperature distribution related to the meteorological conditions during the period and forecasts for further thermal development. When a sufficient number of BWT observations are available the charts are supplemented by maps showing the distribution of the water temperature at the bottom; in spring each year a forecast is added for the development of BWT conditions during the following summer months in the various fishing areas of the North Sea.

Originally the charts and forecasts were only distributed to some scientific institutes and organisations interested in hydrographic and biological studies in the area. As a continuous series of quasi-synoptic charts they are unique material for scientific investigations, such as studies on the high variability of temperature in relation to changes in the meteorological conditions, or studies on the behaviour of commercial fish species in relation to temperature.

The BWT charts and the forecasts for summer temperature conditions at the bottom were specifically introduced for use by fishermen, because the main commercial species in the North Sea are demersal.

11.2.2 Background

Temperature observations in the North Sea have regularly been made at a number of places for more than 100 years. Through collaboration between riverine countries within the framework of the International Council for the Exploration of the Sea (ICES) a large number of additional observations by research and merchant vessels has also been made available. Thus, monthly mean values are known for $\frac{1}{2}^{\circ}$ squares, and charts showing the monthly mean temperature distribution in various depth horizons are published in climatological atlases.

Short-term forecasts for the development of the temperature distribution at the surface - for some days in advance - are based on comparison of actual temperatures with relevant mean values and the general meteorological situation.

Long-term forecasts for the development of BWT are made in spring for a period of some months. They are based on the SST distribution during the winter months and the exchange of heat between the sea surface and the bottom until this exchange is terminated in spring by setting up a strong thermocline in the northern and central area of the North Sea. For the remaining areas some extrapolation must be made considering the actual temperatures with relevant mean values.

11.2.3 Product preparation and distribution

Values used for the preparation of SST and BWT charts are the observations from fixed stations, such as oil rigs and light vessels, from research vessels which transmit sea surface temperatures to the Meteorological Office (Seewetteramt) as part of their 6-hourly weather telegrams. In one week more than 200 such observations are collected; they are used to draw a quasi-synoptic picture of the temperature distribution; in doing so, most recent observations - especially in periods of rapid changes or high variability of the temperature - are given more weight than those made at the beginning of the period. The mean error of the analyses has been investigated and is estimated at ± 0.5°C, with a maximum error of ± 1°C.

Originally the charts were distributed by mail to scientific institutes. For some years they have also been transmitted 6 times a week by facsimile to ships equipped with a suitable receiver (Figure 1). The time delay in the latest incoming temperature observations in a one-week period is only 24 hours.

Fishing vessels equipped with facsimile receivers have used the charts for thermal searching of fish and informed other vessels, in particular, small cutters, by radiotelephone in cases of good results. A growing number of fishermen are therefore becoming interested in the analyses, and plans have been made to extend these to include a description of the actual situation - depth and thickness - of the thermocline.

11.2.4 References

Becker, G., 1970 Bodentemperaturvorhersage für Nordseewasser im Sommer 1970. Inf. Fischwirtsch., 17(2):43-5

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11.3 A fish forecasting service for Canadian fisheries (Proposal)

11.3.1 Introduction

A proposal outlining the organization of a fish forecasting service was presented to the Federal Provincial Atlantic Fisheries Conference in Ottawa in 1964.

A general idea of this proposal was to assist Canadian fishermen by providing them with analyses of oceanographic data and fish catches for the waters around Canada, particularly the Gulf of St. Lawrence, as they are faced with intensive competition by well equipped fishing vessels from many nations.

The service was well devised and, if implemented, could have been of considerable assistance to fishermen. No information was, however, made available about realisation of the proposed service. It may have been difficult to convince both government representatives and fishermen of the benefit of the service without having first shown its effectiveness by carrying out a small pilot experiment. Nevertheless, the system as such seems to be of interest to all scientists planning to establish environmental services. Therefore a short summary of the proposal is given. Further details can be found in the description published by Simmons (1964).

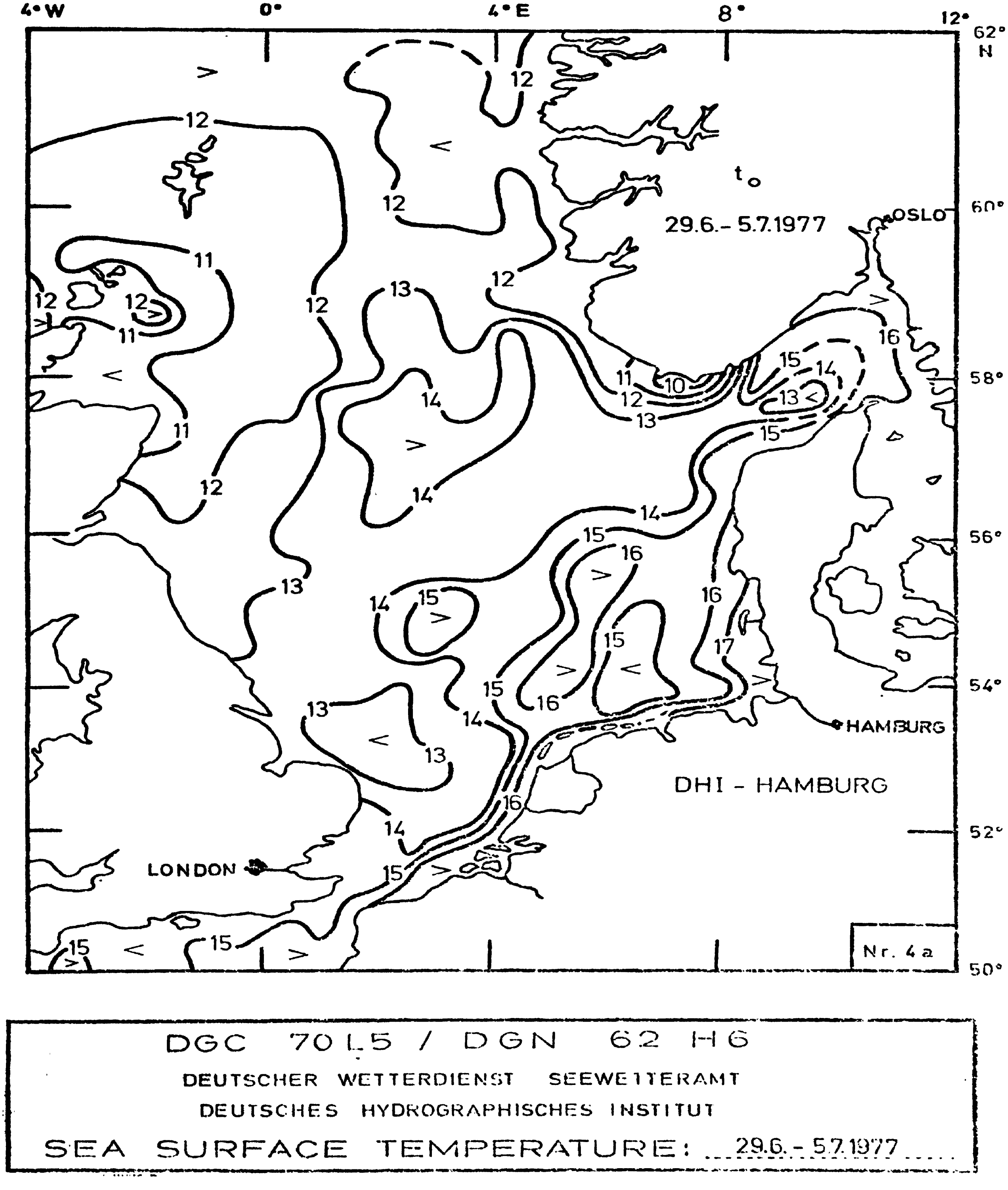

Figure 1: Example of SST chart for the North Sea broadcast by facsimile to users at sea

11.3.2 Data requirements

The following data are envisaged as basic material needed for the preparation of analyses and forecasts:

(i) Fisheries data

The fishing vessels will be provided with forms by which the captains report on the content and position of each haul. On arrival in the fishing harbour the skipper will hand over these reports to the port's Fisheries Officer who will transmit them by telex or other quick landline transmission system to the analyzing center of the service. The catches will be grouped (poor, below average, average, above average, excellent) and charts will be drawn showing results of the fishing activities for each day. It is realised that these will have some days delay as the reports are only delivered on arrival of the fishing boats in the harbour. However, a series of consecutive charts available to the fisheries biologist in the analyzing centre will enable him to prepare the forecasts concerning the concentration of fish in the various fishing grounds.

(ii) Oceanographic data

A few small but specially equipped vessels will gather these data regularly surveying the temperature and salinity distribution in the main fishing areas. The ships will be equipped with automatically operating STD (Salinity/Temperature/Depth) recorders, and it is estimated that coverage of all interesting areas can be done in 10-14 days. The data are recorded on tapes which each day are passed through a special type transmitter and transferred to a similar tape held at the analyzing centre. The centre is equipped with a suitable computer which plots the data on charts. A biological oceanographer will then prepare the analyses (temperature and salinity distribution at the surface, at the bottom and at distinct depths as needed) and forecasts for the oceanographic conditions.

(iii) Meteorological data

The meteorological conditions will be taken into account when advising the fishing fleet on the most suitable locations for their further fishing activities. This will be done using weather maps and/or ensuring direct contact with the nearest meteorological office.

11.3.3 Environmental products prepared by the service

Based on the above data the analyzing centre of the service will provide the users - fishermen, fisheries associations and researchers - with the following products:

(i) Information charts on the concentration of fish, fishing activities and results. The charts will be issued daily but in view of the delay in the incoming data they will show the state prevailing some days earlier. They will however be accompanied by a forecast for the actual state.

(ii) Environmental analyses showing the temperature and salinity distribution in various depths horisons in the fishing areas. A forecast concerning the expected changes in environmental conditions will also be added to these charts.

(iii) Short- and long-term forecasts (days and weeks) concerning migratory movements of fish and expected shifts of the location of most suitable fishing areas. These forecasts will be based on scientific evaluation (correlation of the data made available by the envisaged collaboration between the fishermen and the analyzing centre) and will therefore depend on accumulation of experience of the analysts; the expected interest of users will also lead to a growing number of good observations provided to the service.

11.3.4 Reference

Simmons, R.E., A fish forecasting system. Canad.Fisherman, November 1964, pp.24-28
1964

11.4 Sea surface isotherm maps for tuna fishermen working in areas around the New Zealand coast [1]

11.4.1 Introduction

The increased yearly catch of tuna around the New Zealand coast from 4 tons in 1965 to 500 tons in the early 1970s shows a growing interest in commercial exploitation.

Development of the tuna fishery depends on better knowledge of the fish and suitable catching techniques in New Zealand conditions, but mainly on better information about the distribution of tuna. Even in well developed fisheries up to 80 percent of the fishing is sometimes spent in locating tuna schools, which means that up to 37 percent of the total operating expenses is used only for searching.

Pilot experiments were therefore carried out to determine whether fishermen could be assisted in locating tuna schools by means of sea surface temperature (SST) isotherm maps.

11.4.2 Organization of pilot experiments

Infra-red radiometry carried out from low-flying planes was found of value to scientists in the intepretation of water movements around New Zealand, and since 1969 the New Zealand Oceanographic Institute has organized various flights using a Piper Aztec aircraft and a model IT-3 infra-red radiometer manufactured by the Barnes Engineering Company, Connecticut, U.S.A.

These surveys showed that cells of warm water, eddy formation and distribution, and temperature fronts around these eddies could be detected. The use of such flights for the preparation of SST charts to enable tuna fishermen to locate schools was therefore suggested. In New Zealand conditions albacore prefer temperatures between 17.2° and 21.5°C, southern bluefin between 18.9° and 20°C, and skipjack and yellowfin 20° to 23.3°C, all of them concentrating within these limits, particularly in areas of frontal zones.

Surveys along various parts of the New Zealand coast demonstrated the possibility of preparing SST charts in good time with an accuracy of about 1.1°C; the temperature gradients in frontal zones were shown to be correct to within 0.2°C.

11.4.3 Results and further suggestions

Eventually it was found that the expectations of establishing a clear connexion between albacore distribution and sea surface temperatures could not be met. As areas with temperatures most suitable for the tuna species comprise about two thirds of New Zealand's thousand mile coastline in summer, identification of suitable frontal zones is not feasible. (Roberts, personal communication). It seems that in order to locate tuna schools information about the concentration of suitable food organisms must also be made available.

This will very probably be the case along the Subtropical Convergence Zone which normally crosses New Zealand waters. Plans have been developed to locate this zone with the aid of satellite observations, e.g. the SST charts produced by GOSTCOMP and it is hoped that predictions on the distribution of albacore can be made available from these observations.

11.4.4 Reference

Roberts, P.E. Sea surface isotherm maps for tuna fishermen. Fisheries Research Division, 1971 Information Leaflet No. 2, New Zealand Marine Department, Wellington, 9 p.

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[1] For details see Roberts (1971)

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